TM 8-275

WAR DEPARTMENT

TECHNICAL MANUAL

MILITARY ROENTGENOLOGY

January 26, 1942

TECHNICAL MANUAL
No. 8–275

WAR DEPARTMENT,
WASHINGTON, January 26, 1942.

MILITARY ROENTGENOLOGY

Prepared under direction of
The Surgeon General

SECTION I

GENERAL

1. **Purpose and scope.**—*a.* The field of roentgenology is quite a comprehensive specialty, covering as it does the broad scope of medicine and various aspects of physiology, pathology, and biophysics. It includes a number of subspecialties, any one of which might easily consume a lifetime of effort. For instance, extremely hard-working scientists are devoting full time to a career in roentgen physics; others are concerned entirely with roentgenography; many doctors are devoting their practices to diagnostic roentgenology, while others are confining their efforts to roentgenotherapy.

b. Today, it would be impossible to compile in one volume even the essentials of each of these subfields. Certain aspects of roentgen physics and roentgenography have been presented in TM 8–240. This manual is merely intended to describe those special responsibilities

which are entrusted to the Army roentgenologist and which are additional to the average diagnostical and therapeutic requirements.

Section II

PROCUREMENT AND SUPERVISION OF X-RAY EQUIPMENT

2. General.—The Army radiologist must be acquainted with the normal procedures which pertain to procurement of X-ray equipment and materials and, thereafter, their proper handling. With most civilian institutional connections, the radiologist may sense merely a moral responsibility for protection of the equipment in his department. Unless he has actually purchased it, paying from his own resources, it is quite natural that he should consider it the property of the institution and it is quite unlikely that unserviceability of any part of the apparatus would result in any financial loss to the doctor. Not so in the case of the Army radiologist. Though the equipment belongs to the United States Army, it is necessary that it be entrusted to a responsible individual, an officer. The Army radiologist is therefore held strictly responsible for it. In case proper accounting cannot be made for unserviceabilities or losses, a depreciated value of the equipment may be deducted from the pay of the officer; hence, the importance of his interest in this subject.

3. Requisitioning.—*a.* A listing must be made of the equipment and materials needed, with request that they be obtained by the medical supply officer. These requests serve to initiate requisitions (see par. 7).

b. The listings are compiled according to the character of the items. In general, items are classified as standard or nonstandard.

4. Standard and nonstandard items.—*a. Standard.*—(1) All standard items are listed in the Medical Department Supply Catalog. Therein, they are grouped according to classes. The classification has been made on the basis of general purposes or the type of the commodity in the following manner:

Class 1: Drugs, chemicals (including X-ray processing chemicals, laboratory stains, biological products, articles furnished by medical supply depots, by Army Medical Center, or by corps area or department laboratories.
Class 2: Surgical dressings.
Class 3: Surgical instruments, surgical appliances, miscellaneous diagnostic instruments, and surgical supplies.
Class 4: Laboratory equipment and supplies.
Class 5: Dental equipment and supplies (including dental film-viewing boxes).
Class 6: X-ray equipment and supplies.
Class 7: Furniture, physiotherapy equipment, hospital linen and bedding, mess equipment and supplies, cleaning and preserving equipment and supplies, stationery, miscellaneous office equipment and supplies, miscellaneous hospital equipment and supplies.
Class 8: Veterinary equipment and supplies.
Class 9: Field equipment (including field X-ray equipment) and supplies.

In addition, the supply catalog contains an appendix wherein explanatory information is presented, with the inclusion of photographs.

(2) Thus the radiologist is mainly concerned with class 6 or class 9, class 7, and class 1. Class 6 contains a listing of standard X-ray equipment which might be needed for installations such as the and peacetime installations. Class 9 contains a similar listing of equipment which might be needed for installations such as the mobile hospital or the evacuation hospital in the theater of operations. Class 1 contains the processing chemicals needed for either occasion. For the police and maintenance of the clinic itself, furniture, cleaning items, stationery and miscellaneous office equipment, linen, etc., are listed under class 7.

(3) The listings in the supply catalog include a brief description of the item and one or more symbols which characterize it. These symbols will be found in the second column identified as "Notes" (see fig. 1). The significance of these symbols is as follows:

CLASS 3.—*Surgical Appliances, Miscellaneous Diagnostic Instruments, and Surgical Supplies*

No.	Notes	Item	Unit	Unit Price	Allowance per 1,000	Allowance per 5,000	Allowance per 25,000	1	2	3
36010	(5)	ACOUMETER: Bartlett	Each	$1.50						
36030	X	ADAPTER, KYNARD: For connecting ureteral catheter with Luer syringe.	Each	1.00	1	1	6			
36090	X	ADAPTER TUBING: Male slip joint for attaching Luer needle to rubber tubing	Each	.15	1	2	10			
36095	6	ANESTHESIA APPARATUS, INTRATRACHEAL: Stand and rack	Each	16.50						
36040	6 (1)	ANESTHESIA APPARATUS, NITROUS OXIDE: Oxygen, carbon dioxide, and ether with carbon dioxide absorber	Each	351.23	1	2	4			
36050	X (1) (2)	ANESTHESIA APPARATUS, BAG: For inhaler, rubber.	Each	3.55	R	R	R			
36060	6 (2)	ANESTHESIA APPARATUS, PRESSURE REGULATOR AND GAUGE:	Each	34.42	1	1	2			
36070	X (1) (2)	ANESTHESIA, APPARATUS, RIM FOR FACE, MASK: Rubber.	Each	1.45	R	R	R			
36080	X (1) (2)	ANESTHESIA APPARATUS, RIM FOR NASAL, MASK: Rubber.	Each	.70	R	R	R			
36085	X (1) (2)	ANESTHESIA APPARATUS, TUBING: Rubber, for inhaler.	Each	2.60	R	R	R			
36090	6 (4)	ANESTHESIA AND SUCTION APPARATUS:	Each	160.00	1	1	2			
36095	(2)	ANESTHESIA AND SUCTION APPARATUS, ETHER TIP:	Each	.75	R	R	R			
36100	(2)	ANESTHESIA AND SUCTION APPARATUS, SUCTION TIP:	Each	2.00	R	R	R			
36105	6	APPARATUS, BLOOD TRANSFUSION:	Each	43.00	SO	SO	SO			
36110	X	APPLICATOR, WOOD: 6 gross	Carton	.22	1	4	40			
36120		ATOMIZER, SET OF 4: In rack	Set	3.84	1	2	5			
36122	X (3)	ATOMIZER SET, BOTTLE: (Also replacement for 36510).	Each	.09	R	R	R			
36130	6 (4)	AUDIOMETER: Aurograph type	Each	200.00	SO	SO	SO			
36160	X (1)	BAG, POLITZER: 6 oz, with valve	Each	.28	1	2	5			
36170	(2)	BALKAN FRAME: Complete Figs. 17-20, M&A, 1934	Each	16.71	1	4	20			
36175	X	BALKAN FRAME, BAG, BUCKSHOT, 8-INCH: By 8-inch, 14-inch opening, canvas, will hold 1 lb.	Each	.02	R	R	R			
36177	X	BALKAN FRAME, BAG, BUCKSHOT, 8-INCH: By 8-inch, 14-inch opening, canvas, will hold 5 lbs.	Each	.03	R	R	R			
36179	X	BALKAN FRAME, BAG, BUCKSHOT, 8-INCH: By 9-inch, 8-oz duck, with handle, open mouth, for holding buckshot bags.	Each	.04	R	R	R			

FIGURE 1.

Symbol	Significance
X	Expendable.
No mark or a series of eight dots.	Nonexpendable.
$	Expensive items.
(1)	Deteriorating.
(2)	Refer to appendix for description of item, formula, contents of case, etc.
(3)	Requisition should state manufacturer, type, description, size, and serial number of item or part required.
(4)	Requisition should state voltage, current, d-c or a-c (if a-c, cycle and phase), or kind of gas, steam, etc.
(5)	Item will not be issued to hospital smaller than 50 beds.
("SG")	Under allowances, indicates that prior authority must be obtained from The Surgeon General to requisition. The necessity of such items will be clearly stated.
(c)	Controlled items. Request for the disposition of such items should state classification under paragraph 5, AR 35-6640, date of receipt and source, manufacturer, model, serial number, nature and manner of unserviceability, or the estimated cost of repair.

(4) Standard items are stocked in general depots and issued to the various hospital installations when requisitioned and, if it is deemed proper by the office of The Surgeon General that the particular installation be allocated, either the type or the quantity requested. Approximately 90 percent of the items used by the Medical Department are standard items.

(5) Replacement and spare parts for standard items are not usually listed in the Medical Department Supply Catalog and should be secured on quarterly nonstandard or emergency nonstandard requisitions in the manner directed by AR 40-1705 and current circular letters issued from the medical supply office. (See figs. 7 and 8.)

b. Nonstandard.—Items which are not listed in the supply catalog but which might be needed for particular purposes are called nonstandard items. They are not ordinarily carried in stock but are obtained either by local purchase (if local funds are available) or by requisition on a general depot. (See figs. 8 and 9.)

5. Expendable and nonexpendable supplies.—Medical supplies are further classified for stock record accounting as expendable and nonexpendable.

a. Expendable items include those items which are to be consumed in service. As listed in the supply catalog, they are identified by the letter "X." It is usually taken for granted that they will be used within 12 months from the time of their being issued. X-ray films, stationery, chemicals, cleaning materials, lubricants, etc., are examples of expendable items. Records of these items are not ordinarily required by stock record cards (that is, in the files of the medi-

cal supply officer) though the radiologist must bear responsibility for waste or loss of them.

b. Nonexpendable items include those items which are not consumed by use and which, due to their cost and length of life in service, must be accounted for on the stock record account of the medical supply officer. As listed in the supply catalog, they are identified by not having the letter "X" in the "Notes." The radiologist must be able to account for all such items which have been entrusted to him, in accordance with the listings on individual memorandum receipts or consolidated memorandum receipts compiled by the medical supply officer (see par. 9).

6. Deteriorating and nondeteriorating supplies.—Both expendable and nonexpendable items are further classified as deteriorating or nondeteriorating.

a. A deteriorating item is one which, whether used or not, might be expected to become unserviceable within a period of 1 to 2 years after being issued. X-ray films and printing paper are examples of expendable deteriorating items, while lead aprons and lead gloves are examples of nonexpendable deteriorating items.

b. A nondeteriorating item is one which can reasonably be expected to be serviceable for a period of time longer than 2 years. Most of the items in the Medical Supply Catalog are nondeteriorating.

7. Initiating requisition.—*a.* The official form, W. D., Q. M. C. Form No. 400 (Requisition), is used by the medical supply officer for compiling the actual requisition. The radiologist directs his requests for supplies to the medical supply officer by means of issue slips or memoranda which serve to initiate the actual requisitioning. All of these forms identify standard versus nonstandard supplies; the character of either in terms of expendable, nonexpendable, deteriorating, or nondeteriorating items; and the character of the request or requisition with respect to the period of the fiscal year covered.

b. To indicate these purposes, the following forms may be used by the radiologist:

(1) W. D., M. D. Form 16a (Issue Slip, Expendable Medical Property) (white), Medical Department, is actually an issue slip but it provides for requesting expendable items which are ordinarily consumed from week to week—items such as listed in figure 2.

(2) W. D., M. D. Form 16b (Issue Slip, Nonexpendable Medical Property) (blue), Medical Department, is also an issue slip but it is actually used as a request for nonexpendable items included in stock supplies in the local warehouse of the medical supply officer. (See fig. 3.)

Form 16a
MEDICAL DEPARTMENT, U. S. ARMY
(Revised April 21, 1939)

ISSUE SLIP

EXPENDABLE MEDICAL PROPERTY

TO THE MEDICAL SUPPLY OFFICER: Please issue the following for use in X RAY CLINIC

ITEM No.	ARTICLES	UNIT	QUANTITIES	
			On hand	Required
60050	BRUSH, CAMEL HAIR	EA	0	1
60330	HOLDER, FILM EXPOSURE, 8 IN.	EA	4	8
61120	OIL, TRANSFORMER	GAL	0	5

I CERTIFY that I have personally verified the quantities on hand, that the amounts shown are correct, and that the quantity requested is necessary to meet actual requirements.

H.R. Van Blaricon
H.R. VAN BLARICON, 2ND LT., M.A.C.
Officer in Charge.

Issue articles and quantities, as altered:

F.R. Wintker
F.R. WINTKER, 1ST LT., SAN. CORPS.
Medical Supply Officer.

Received:

Wesley Moore
WESLEY MOORE, ST. SGT., MED. DEPT.
Warrant Officer.

Date AUGUST 4, 1941

3—3001

FIGURE 2.

Form 16 b
MEDICAL DEPARTMENT, U. S. ARMY
(Authorized Jan. 21, 1916)

ISSUE SLIP

NONEXPENDABLE MEDICAL PROPERTY

TO THE MEDICAL SUPPLY OFFICER: Please issue the following for use in X RAY CLINIC

ARTICLES		QUANTITIES
60090 CASSETTE, 8 X 10 INS. WITH 2 INTENSIFYING SCREENS	EACH	10
61660 TANK, 4 1/2 INCH BY 14 3/4 X 20 INCHES,	EACH	2

John Roe
JOHN ROE, CAPT. M. C. *Officer in Charge.*

Issue articles and quantities, as altered:

A. W. Loe
A.W. LOE, CAPT. MAC *Medical Supply Officer.*

Received:

G. D. Doe
G.D.DOE, PVT. *Wardmaster.*

Date MAY 15, 1941

ORIGINAL

3—3693

FIGURE 3.

(3) Standard deteriorating items are requested quarterly in time for the medical supply officer to requisition them March 1, June 1, September 1, and December 1. These are items which are not ordinarily carried in the stock of the medical supply officer. (See fig. 4.)

(4) Twice yearly, an estimate is developed as to needs of standard items not contained in the supply of the local medical supply officer. These items are of a relatively inexpensive character (therefore not captioned "SG" in their listing in the medical supply catalog). This estimate is developed by way of a memorandum which must reach the

ARMY MEDICAL SCHOOL
ARMY MEDICAL CENTER
DEPARTMENT OF ROENTGENOLOGY
WASHINGTON, D. C.

MAY 15, 1941.

MEMO TO: THE MEDICAL SUPPLY OFFICER, POST.

1. IN COMPLIANCE WITH YOUR MEMORANDUM NO. 22, DATED MAY 9, 1941, THE FOLLOWING ESTIMATE FOR SUPPLIES IS HEREBY SUBMITTED:

A. STANDARD QUARTERLY DETERIORATING SUPPLIES FOR THE PERIOD REQUESTED.....

60020 APRON, LEAD: IMPREGNATED RUBBER, 24 BY 33 INCHES. EACH 2

60300 GLOVES, OPAQUE, PROTECTIVE PAIR 2

John K. Roe
JOHN K. ROE, CAPT., M.C.
DIRECTOR.

JR/HV

FIGURE 4.—Quarterly request for standard deteriorating supplies.

local medical supply officer prior to March 1 or September 1. (See fig. 5.)

(5) Twice yearly, an estimate must be developed, listing the more expensive (nonexpendable) items which require the authority of The Surgeon General for their purchase and issue. This estimate is compiled on a memorandum to the local medical supply officer and must reach him prior to April 1 or August 1. (See fig. 6.)

(6) In case an item is desperately needed because of an unexpected requirement or sudden breakdown of equipment, an emergency request may be initiated. This may be submitted at any time on a memorandum to the local medical supply officer. (See fig. 7.) This type of request should be avoided as much as possible since it requires special provisions as to funds, etc.

c. Nonstandard items may be obtained by—

(1) Listing such items on a memorandum described as "Quarterly Nonstandard Medical and Dental Supplies." This estimate should

ARMY MEDICAL SCHOOL
ARMY MEDICAL CENTER
DEPARTMENT OF ROENTGENOLOGY
WASHINGTON, D. C.

FEB. 16, 1941.

MEMO TO: THE MEDICAL SUPPLY OFFICER, POST.

1. IN COMPLIANCE WITH YOUR MEMORANDUM NO. 22, DATED FEBRUARY 9, 1941, THE FOLLOWING ESTIMATE FOR SUPPLIES IS HEREBY SUBMITTED:

A. STANDARD SUPPLIES, SEMI ANNUAL.

ITEM NO.	ITEM	UNIT AND	AMOUNT
60079	CALIPER, RULE TYPE	EACH	1
60200	FILTER, 1 MM. THICK	EACH	8
60310	GOGGLES, OPERATORS	PAIR	3
60400	ILLUMINATOR, RADIOGRAPHIC	EACH	2
60490	LIGHT, SAFE: DARK ROOM	EACH	8
61675	TANK, DEVELOPING: 3 COMPARTMENT, WITH INTAKE, OVERFLOW AND OUTLET FITTINGS.	EACH	1
61677	TANK, DEVELOPING BASE: MOUNTED ON CAST IRON LEGS.	EACH	1

A. A. DE LORIMIER,
MAJOR, MEDICAL CORPS,
DIRECTOR, DEPARTMENT OF ROENTGENOLOGY.

AAD/HRV

FIGURE 5.—Semiannual request for standard nondeteriorating supplies.

be in the hands of the medical supply officer prior to March 1, June 1, September 1, or December 1. (See fig. 8.)

(2) If local funds are available, nonstandard items may be purchased by a local purchase order, in which case a request is submitted to the medical supply officer. (See fig. 9.)

d. All correspondence of this character is conducted directly between the X-ray department and the medical supply officer. The commanding officer of the hospital or medical installation later

reviews all requests and requisitions as compiled by the medical supply officer.

8. Periodic estimates.—The local supply officer must anticipate the needs for the hospital as a whole and he may request estimates as to requirements of standard and nonstandard equipment for a stated future period. Such estimates are usually made out informally. They are most likely to cover deteriorating items.

ARMY MEDICAL SCHOOL
ARMY MEDICAL CENTER
DEPARTMENT OF ROENTGENOLOGY
WASHINGTON, D. C.

MARCH 15, 1941.

MEMO TO: THE MEDICAL SUPPLY OFFICER, POST.

1. IN COMPLIANCE WITH YOUR MEMORANDUM, DATED MARCH 9, 1941, THE FOLLOWING ESTIMATE FOR S G ITEMS IS HEREBY SUBMITTED:

60890	MACHINE, X RAY, STATIONARY, COMPLETE: TO OPERATE ON 220 VOLTS, A.C., SINGLE PHASE, 60 CYCLE CURRENT.	SET	1
61360	STEREOSCOPE, COMPLETE	EACH	1

A. A. DE LORIMIER,
MAJOR, MEDICAL CORPS,
DIRECTOR, DEPARTMENT OF ROENTGENOLOGY.

AAD/HRV

FIGURE 6.—Semiannual request for expensive nonexpendable items (requiring special authority of The Surgeon General).

9. Handling of property.—*a.* The actual professional duties of the radiologist are usually so extensive that it is not possible for him personally to attend to all the details for which he is responsible. Ordinarily, the writing of requisitions, the coordinating with the local supply officer, and the keeping of departmental stock records are duties which are delegated to a trustworthy sergeant or to some other one of the enlisted personnel. However, this does not relieve the officer of his responsibility. When property is issued, the medical supply officer receives for it a memorandum receipt signed by the receiving and responsible officer. A duplicate copy of this memorandum receipt is kept on file in the department. (See fig. 10.)

b. As property is issued from time to time, a number of these receipts are accumulated. At intervals, there may be developed a compiled memorandum receipt. Either the separate listings or the compiled record should be used for interval checking of the property. Paragraph 19*a*(2), AR 35–6520, as amended by section III, Circular No. 30, W. D., A. G. O., February 20, 1941, states that inventory of property will be made by the "responsible officers annually, or more

ARMY MEDICAL SCHOOL
ARMY MEDICAL CENTER
DEPARTMENT OF ROENTGENOLOGY
WASHINGTON, D. C.

JULY 4, 1941.

MEMO TO: THE MEDICAL SUPPLY OFFICER, POST.

SUBJECT: EMERGENCY REQUISITION FOR MEDICAL SUPPLIES.

1. REQUEST THAT THIS DEPARTMENT BE FURNISHED WITH THE FOLLOWING NEEDED EQUIPMENT:

GLASS LEAD, FOR USE AS PROTECTIVE COVERING FOR FLUOROSCOPIC SCREEN. SIZE: 14 X 17 INCHES, SELECTED QUALITY, APPROXIMATE COST: $20.00.

2. THIS ITEM, GLASS LEAD, IS URGENTLY NEEDED TO REPLACE PRESENT GLASS ON OUR FLUOROSCOPIC UNIT WHICH IS CRACKED AND PERMITS THE PASSAGE OF X RADIATION TO THE RADIOLOGIST.

A. A. DE LORIMIER,
MAJOR, MEDICAL CORPS,
DIRECTOR, DEPARTMENT OF ROENTGENOLOGY.

AAD/HRV

FIGURE 7.—Emergency requisition.

often if the commanding officer requires it." Usually the local commanding officer requires that these inventories be accomplished each month. Each nonexpendable item should actually be seen. In the case of expendable items, the number on hand should be subtracted from a quantity received during the month and thereby the consumption analyzed.

10. Accounting for consumption of X-ray films.—*a.* Illegal sales have been made of all types of Government property but in particular "consumption" of X-ray films must be watched. It is advisable that films be stored within a locked cabinet or a locked room

and that the key to such be held by one person in the department. A tabulated record of quantities received versus quantities removed from this storage should be posted within this cabinet or room. This record should include the date, the film size, and the quantity

ARMY MEDICAL SCHOOL
ARMY MEDICAL CENTER
DEPARTMENT OF ROENTGENOLOGY
WASHINGTON D. C

FEB. 14, 1941.

MEMORANDUM TO: THE PROPERTY OFFICER, ARMY MEDICAL SCHOOL,
THRU: THE DIRECTOR, ARMY MEDICAL SCHOOL,
POST.

SUBJECT: ESTIMATE FOR QUARTERLY NON STANDARD SUPPLIES.

1. IN COMPLIANCE WITH YOUR MEMORANDUM DATED FEBRUARY 8, 1941, THE FOLLOWING ESTIMATE FOR NON STANDARD MEDICAL AND DENTAL SUPPLIES IS HEREBY SUBMITTED:

CAT.NO.	ITEM	UNIT	AMT.	PRICE
4897	SOLDERLESS LUGS NO. 4 TO NO. 8	EA.	100	$ 5.23
6202	HACK SAW BLADES, 10 INCH, 24 TEETH	EA.	144	6.00
		TOTAL		$ 11.23

ABOVE ITEMS CAN BE PURCHASED FROM,

AMERICAN ELECTRICAL SUPPLY CO.,
329 WEST MADISON STREET,
CHICAGO, ILLINOIS.

130	SET OF EIGHT TURNING TOOLS	EA.	1	$ 7.50

ABOVE ITEMS CAN BE PURCHASED FROM,

DELTA MANUFACTURING CO.,
MILWAUKEE, WISCONSIN.

JOHN ROE, CAPT., M.C.
DIRECTOR.

JR/HV

FIGURE 8.—Quarterly nonstandard requisition.

concerned with each increment or issue, together with the initials of the individual concerned. This record need not be elaborate but it should be complete.

b. In larger X-ray clinics, besides keeping a record of all films received and all films issued, it is advisable that each roentgenographic technician and also those concerned with processing in the

darkroom be required to report the total number of films used or handled each day or each week, as well as the number of films wasted.

Pur. Ordor No.

ARMY MEDICAL CENTER
MEDICAL DEPARTMENT PROFESSIONAL SERVICE SCHOOLS,
Washington, D. C.

MAY 15, 1941.

MEMORANDUM TO: The Medical Supply Officer, Post.

1. Request that the articles listed below be furnished for use in

DEPARTMENT: DEPARTMENT OF ROENTGENOLOGY

DIVISION: RESEARCH AND TESTING

Cat. No.	Item:	Unit:	Quantity	Total Cost:
.....	SINGLE EMULSION FILMS EXPERIMENTAL FOR PHOTOROENTGENOGRAPHY, SIZE: 4 X 10 INCHES.	DOZ.	12	$ 11.48

THESE FILMS CAN BE PURCHASED FROM:

THE SUPER SPEED FILM CO.,
149 W. MOORE STREET,
GAS CITY, INDIANA.

CHARGE TO: SPECIAL FUND NO. 4088 : PROJECT: RESEARCH

I CERTIFY that the above-named non-standard items are needed in the Army Medical School, that there are no suitable substitutes on the standard Medical Supply Table, and same is not available at the Army Medical School.

John Roe
Chief of Division:
JOHN ROE, CAPT., MC,
DIRECTOR.

APPROVED:
FOR THE ASSISTANT COMMANDANT:
DON LONGFELLOW, Major, Medical Corps

APPROVED: RALPH W. FRENCH, Major, SN-Corps.
Property Officer.

FIGURE 9.—Purchase order.

This system provides for checking the reports of the individual roentgenographic technicians with the summation report by the technician or technicians in the processing room, and both reports

with the records contained in the film cabinet or film storage room. Usually, the psychological effect of such a system will counteract any inclination toward "bootlegging" of X-ray films.

MEMORANDUM RECEIPT
XXXXXX • DEBIT SLIP

*Issued to } X RAY CLINIC
*XXXXXXXX

Place ARMY MED. SCHOOL Date MAY 15, 19 41

MEDICAL Property
(Name of supply branch)

NO.	STOCK NO.	ARTICLES
10	60090	CASSETTE, 8 X 10 INCH, WITH 2 INTENSIFYING SCREENS.

Received the above-named articles.

(Signature with rank and organization)
JOHN ROE, CAPT., M. C.
No. OFFICER, IN CHARGE
(Office designation)

O. M. C. Form 487
Revised May 14, 1941 *Strike out words not applicable. O G P O

FIGURE 10.

11. **Accounting for intensifying screens.**—There is a similar temptation for certain people to enter into illegal sales of intensifying screens. These screens are very expensive. They can easily be

removed from cassettes and second-hand screens, or blank cardboards may be used as substitutions. Because of such practices, it is advisable to identify each screen with the words "Property of the United States Government." This description might be written with indelible ink along a margin of the screen whereby the wording will not be reproduced onto useful portions of the roentgenograms. If these captionings are accomplished in the handwriting of the radiologist, there will be provided a challenge in case screens are found in the department which do not bear his handwriting or that of his predecessor.

12. Accountability and responsibility.—An accountable officer is one who conducts a stock record account and who must be in position at all times to account for all items charged against the entire hospital installation or post. This officer is responsible for property storage, issuing, and accounting, and the maintenance of records, files, and inventories. He is the medical supply officer. In contradistinction, a responsible officer is an officer to whom Government property has been entrusted. Usually, there is one officer in each department responsible for its property. He is responsible for all properties which have been issued to him by memorandum receipts. The radiologist is ordinarily one of the property "responsible officers."

13. Property credits. *a.* Several conditions might arise wherein responsibility for certain items should not be incurred or continued. For instance, supplies might be unserviceable because of damage when received in the department; deteriorating items might become unserviceable through "fair wear and tear"; nonexpendable (standard or nonstandard) items might become unserviceable through "fair wear and tear"; property might be damaged, destroyed, or might disappear through no fault or neglect of the personnel of the department (or the same may happen because of carelessness or even willful intent). As long as an item is listed on a memorandum receipt, responsibility for it continues whether it is serviceable or not. If an inspecting officer discovers that an item or items are unserviceable or missing, the radiologist may be ordered to explain these discrepancies or to pay for them. Moreover, even though unserviceable, all items listed on memorandum receipts are charged against the department; these records may interfere with the obtaining of very much needed equipment. Therefore, credits should be obtained promptly for all useless charges.

b. If property is damaged when received by the department, the medical supply officer should immediately be notified. This measure instigates development of an "over, short, and damaged" report by

the medical supply officer. The item is charged against the department pending the outcome of the "O., S., and D." report. Usually, the item is eventually returned to the medical supply officer and adjustments of the records are made or the item is replaced or repaired.

c. When a nonexpendable item becomes unserviceable "through fair wear and tear in military service," credit may be obtained. W. D., M. D. Form 16c (Credit Slip—Nonexpendable Medical Property)

Form 16 c
MEDICAL DEPARTMENT, U. S. ARMY
(Authorized Jan. 21, 1916.)

CREDIT SLIP
NONEXPENDABLE MEDICAL PROPERTY

TO THE PROPERTY OFFICER: The following articles no longer needed are turned in from X RAY CLINIC, ~~A. M. S.~~

ARTICLES	QUANTITIES
61305 SCREEN, INTENSIFYING BACK, 14 INCH, BY 17 INCHES.	1

THIS ITEM HAS BECOME UNSERVICE ABLE THRU FAIR WEAR AND TEAR IN THE MILITARY SERVICE, THRU THE FAULT OF NO ONE CONCERNED.
LENGTH OF SERVICE: 8 YEARS.

John Roe
JOHN ROE, CAPT., M. C.
OFFICER IN CHARGE.

John Roe
JOHN ROE, CAPT., M. C. *Officer in Charge.*

Approved:
Arthur W. Loe
ARTHUR W. LOE, CAPT., M.A.C. *Property Officer.*

Received into storage:
K. C. Shook
K. C. SHOOK, SGT. MED. DEPT. *Storekeeper.*

Date MAY 15, 1941.

Ed. Jan. 21-16—1,500,000 ORIGINAL 8—3095

FIGURE 11.

(pink), should be used, listing the item number, description or nomenclature of the item, the unit, and quantity of the item or items being returned. This slip must be signed by the responsible officer. It must include a statement to the effect that "I certify that the articles of medical supply property listed hereon have become unserviceable through fair wear and tear in the military service through no fault or neglect of anyone concerned." If the item or items are controlled (identified by the symbol "C" in the "Notes" column of the supply catalog), this credit slip must contain all information described in paragraph 4*a*(3) (that is, classification under par. 5, AR 35–6640, date of receipt and source, manufacturer, model, serial number, etc.).

d. The above procedure is also followed in the case of deteriorating items.

e. When property is (willfully or accidentally) damaged, destroyed, or disappears through the fault of the department personnel, the radiologist must institute a survey, W. D., A. G. O. Form No. 15 (Report of Survey), together with affidavits, signed by a notary public or the adjutant, containing statements and all pertinent facts relative to the item or items being surveyed. These data are submitted to the medical supply officer. A survey officer then takes action regarding final disposition of the charge. If the survey is approved, the radiologist is relieved of responsibility and given credit for the item or items (note that affidavits are needed here while not necessary on a W. D., I. G. D. Form No. 1 (Inventory and Inspection Report) instituted by a medical supply officer).

f. The same procedure must be followed in order to receive credit for items which become unserviceable or disappear (because of theft or fire) through no fault or neglect of the personnel of the department, though in such cases no charges are included against enlisted personnel or other parties.

g. Upon receipt of credit requests covering unserviceable properties, the medical supply officer may institute a W. D., I. G. D. Form No. 1. (See AR 20–35.)

14. Transfer of property. *a*. It is customary for officers in the service to be transferred after a certain length of time. Therefore, it is necessary to transfer the responsibilities for the property of a department. The following is the ordinary procedure. The officer assuming responsibility for the property obtains from the medical supply officer a list of property which is charged against the department (as listed on the memorandum receipts). After checking this list and identifying each item in the department, the officer (the new officer) advises the medical supply officer, in writing, of all

REPORT OF SURVEY

MEDICAL (Class of property, ordnance, medical, etc.) Property ARMY MEDICAL CENTER, WASHINGTON, D. C. (Stock record account and station)

Accountable officer HENRY ZOE, CAPT., MAC Date MAY 15, 1941.

STOCK NO.	ARTICLES	QUANTITY	TOTAL COST	DISPOSITION: DESTROY	DISPOSITION: SALVAGE	DISPOSITION: OTHER
60090	APRON, LEAD, IMPREGNATED RUBBER, 24 X 33 INCHES	1	$ 13.34			
		Grand total	$ 13.34			

DATE AND CIRCUMSTANCES

ON APRIL 2ND, 1941, A FIELD TRIP WAS MADE TO CARLISLE BARRACKS, PENNSYLVANIA. NUMEROUS ITEMS CONCERNED WITH ROENTGENOGRAPHY WERE TAKEN ALONG TO BE USED IN DEMONSTRATIONS. PART OF THIS EQUIPMENT WAS THREE .3. LEAD RUBBER APRONS. UPON RETURN TO THIS STATION FROM THE TRIP ONLY TWO .2. OF THE APRONS COULD BE LOCATED. CORRESPONDENCE WITH THE C.O. AT CARLISLE, REVEALED THAT THE APRON HAD NOT BEEN LEFT THERE. A THOROUGH SEARCH HERE HAS BEEN MADE. DESIRE ACCOUNTABILITY AND RESPONSIBILITY RELEASE.

AFFIDAVIT

I do solemnly swear (or affirm) that the articles of public property shown above were lost, damaged, or destroyed as stated, in the manner stated, while in the public service.

R. T. MYERS, 6035267
PVT 1CL, MED. DEPT.
(Grade and organization)

Subscribed and sworn to (or affirmed) before me at ARMY MED. CENTER,

this 16 day of MAY, 19 41

T. G. HESTER, ADJUTANT, MAJOR, M. A. C.
(Grade and organization or title, if notary public, affix seal)

CERTIFICATE

I certify that the loss, damage, or destruction of the articles of public property shown above was caused [illegible] without fault or neglect on my part.

JOHN ROE, CAPT., M.C.
(Grade and org., accountable or responsible officer)

Hq.
Station
Date
To

who is appointed surveying officer.

By order of

Adjutant.

Property Voucher No.

W. D., A. G. O. Form No. 15
July 18, 1918

FIGURE 12.

overages and shortages. The medical supply officer then advises the responsible officer (the officer to be relieved) of the overages and shortages which can be adjusted. Those items which cannot be adjusted are then listed on a report of survey such as shown in figure 12. This report is made out by the responsible officer (the officer to be relieved) in accordance with paragraph 8, AR 35–6640.

b. When the new officer assumes responsibility for the property, he is furnished a memorandum receipt, listing all property charged against the department and which he has found and accepted. This is a compiled memorandum receipt. The original copy of it is signed by the new officer and returned to the medical supply officer. A duplicate copy is retained in the department. The transfer is then complete.

15. Supplies in theater of operations.—When engaged with activities in the theater of operations, being confronted with actual combat, the distribution and handling of supplies must be greatly simplified. However, the same degree of responsibility as described above should be exercised. For detailed description concerning administration of supplies in the field, see paragraph 34, FM 8–10.

Section III

FIELD X-RAY EQUIPMENT

16. General.—*a.* For the theater of operations, the designing of X-ray equipment has been governed by at least three axiomatic principles:

(1) Versatility of adaptation to the extent that each piece of equipment may function not merely for a single purpose but for several requirements and installations.

(2) Portability to the extent that disassemblage of each item can be easily accomplished and that the component parts can be easily carried, the weight of any one part not exceeding 200 pounds.

(3) Practicability of design to the extent that the equipment can serve the requirements of function in peacetime installations as well as in the zones of combat.

b. Relative to this last principle, this equipment should be thoroughly understood by those who are to use it under occasions of combat. A thorough acquaintanceship as to handling it can best be obtained by using it day after day for ordinary routine activities. Moreover, it is reasonable that usage of this equipment in time of peace might lead to improvements in its design, from time to time, so that it will not be necessary on mobilization day suddenly to develop new designs in order to incorporate new principles which may be discovered. This last policy provides for two further attributes:

(1) A war reserve stock of supplies whereby, in case of a sudden emergency, equipment will be available for moving into the field without awaiting supply from manufacturers.

(2) On the basis of expected more or less steady purchasing, the manufacturers will be informed as to just what the Army would need in larger quantities on mobilization day, so that they will therefore have set up the necessary jigs, dies, and other tools for large-scale uniform constructions.

17. Supply catalog listings.—Following these plannings, nine items have been developed for X-ray service. These nine items are included under the general item No. 96010 which consists of component units, captioned as follows:

Item No. 96025, X-ray Field Unit, Chest, Film, X-ray; complete with lead lining.

Item No. 96055, X-ray Field Unit, Dryer and Loading Bin Combination; complete with air circulator, for field processing unit.

Item No. 96060, X-ray Field Unit, Generator, Gasoline, Electrical; complete in chest.

Item No. 96070, X-ray Field Unit, Portable Grid; for use with Item No. 96145.

Item No. 96085, X-ray Field Unit Machine, for field fluoroscopy, roentgenography, and superficial roentgenotherapy, complete in chest.

Item No. 96090, X-ray Field Unit, Mobile X-ray Chassis; for converting item No. 96085 into a mobile unit for ward usage.

Item No. 96115, X-ray Field Unit, Processing Unit for Darkroom; for film processing.

Item No. 96145, X-ray Field Unit, Table Unit: for field fluoroscopy, foreign body localization, and roentgenography, complete in chest.

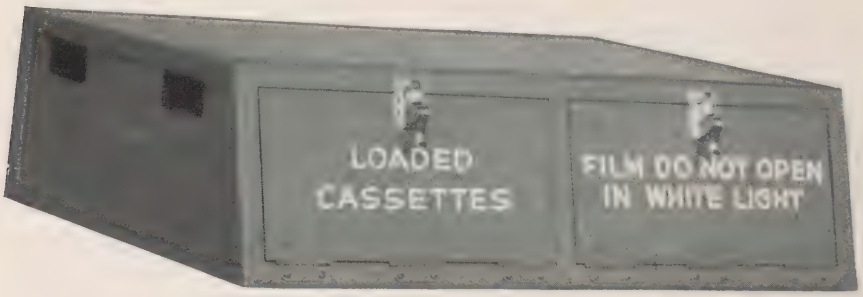
Item No. 96175, X-ray Field Unit, Tent, Darkroom: for fluoroscopy and/or film processing.

18. Film chest.—*a.* Item No. 96025 is simply a standard Medical Department field chest containing an inner lining of sheet lead. The sheet lead is of such thickness (approximately 1.5 mm) that, with the capacity of the chest itself, there is provided protection against X-rays having a quality such as produced with kilovoltages as great as 100. Since it is anticipated that most of the film processing will be done within the tent (item No. 96175), which is nonprotective against X-radiation, it is important that all reserve films be kept in this chest. The usual wall protection afforded by a properly constructed darkroom likely would not be available.

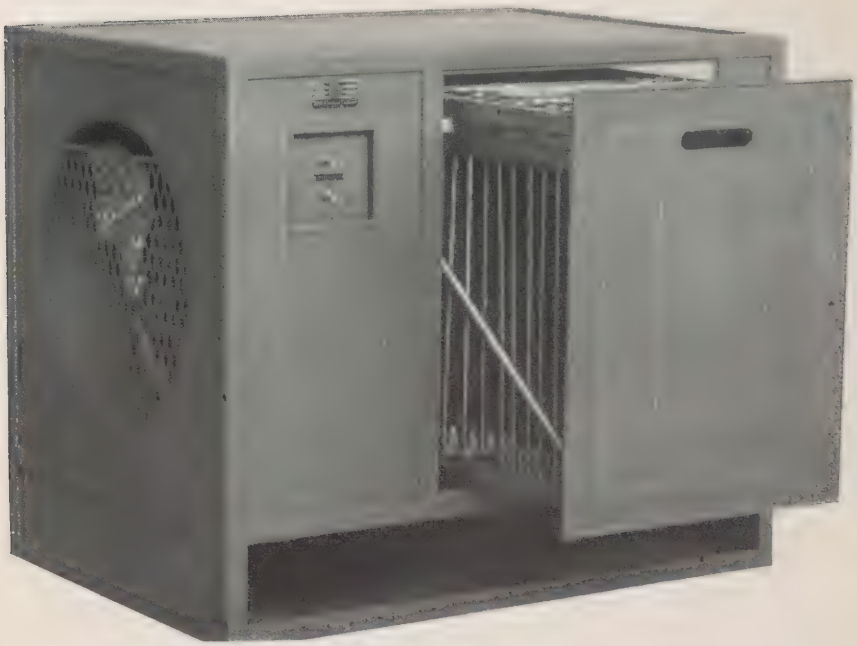
b. This special chest is for use particularly at the evacuation hospital and for those occasional times when films would be wanted for use in a truck at the mobile surgical hospital. It is not recommended for the shipment of cassettes, cardboard holders, or film preservers. These should be packed in the ordinary Medical Department chests. The additional weight of the lead lining contained in the special chest is unnecessary and would be undesirable.

19. Film loading bin, dryer, and loading bench combination.—Item No. 96055 is intended for evacuation hospitals, general hospitals, and station hospitals. Occasionally it may be needed for use in a truck. It is easily portable, being composed of two compartments. The upper compartment is completely lead-lined so as to afford protection against X-radiation. It consists of two sections: a film storage section occupying the right half, and a loaded cassette section occupying the left half. Racks have been provided in each of these two sections to accommodate the three standard dimensions of X-ray films as used by the United States Army: 8- by 10-inch, 10- by 12-inch, and 14- by 17-inch films. The lower compartment of the unit contains a drawer type of drying rack, a heater, fan, and a floor loading shelf. The drying rack has accommodations for 18 films (as suspended on standard film hangers). After mounting the upper compartment (the film and cassette loading bins) onto the lower compartment (the dryer), there is provided a loading bench. The fixation of these two compartments is accomplished by means of a spring type of lock which will be found on the inside of the base compartment and beneath its top. This lock must be

disengaged before attempting to disassemble this unit in case of having to move it to a new installation. These construction features are indicated in figures 13 and 14.



① Film and cassette loading bin.



② Dryer.

FIGURE 13.

20. Gasoline generator.—*a.* Item No. 96060 is a specially designed gasoline electrical generator. It is intended particularly for use with the mobile surgical hospital and for emergency needs at other hospital installations. Its functioning capacity is such as to permit the delivery of 2,500 watts at unity power factor. No

small, portable electrical generator other than that with the identification "Item 96060" should be used to operate the X-ray machine. When the capacity load of a generator is taxed, there ordinarily results a slowing down in the speed of its action. With a sudden release of the load, as intermittently occurs during fluoroscopy, the engine is likely to "race" unless its governor control is adequate. Since X-ray machines function by way of two main

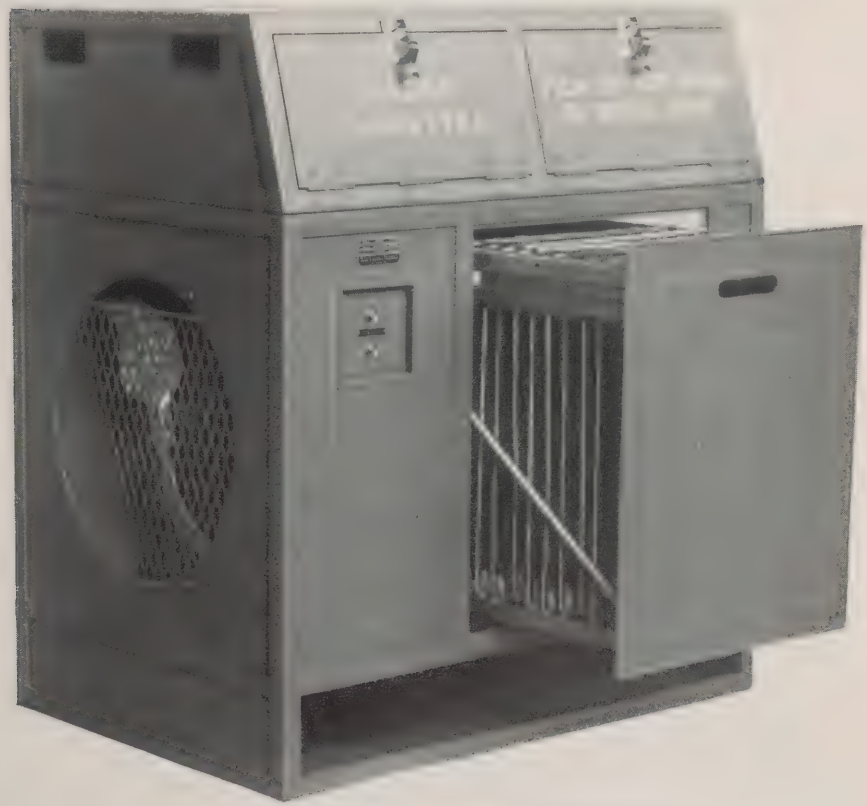


FIGURE 14.—Unit assembled as loading bench.

avenues of circuits (the autotransformer and the main transformer circuits as one avenue of load, and the filament transformer circuit as a parallel avenue of load), when the load of one avenue is released, the load of the other avenue is likely to be increased. Extensive testings have proved that with certain types of portable gasoline electrical generators the governor action is so inadequate in this respect that with release of the main X-ray load there results an overload upon the filament of the X-ray tube, and the filament is

soon destroyed. The caption "Item 96060" has been applied to generators which have been tested at the Army Medical School and which have been found satisfactory in this respect. The requirement of immediate response to the governor is only one of the prerequisites. It is a most important one, however. Other performance characteristics required include—

(1) Surge voltage.
(2) Inverse voltage.
(3) Distortion of wave form.

b. These characteristics are especially important because of utilizing self-rectification and because of having the X-ray tube detached from the high-tension transformer with connections by way of shockproof cables. When operating with the X-ray machine unit, the surge or inverse voltage must not exceed the useful voltage by more than 15 kvp with the useful kvp of 85 and a milliamperage of 25. The kilovoltage calibrations of the prereading voltmeter have been made on the basis of the wave form of the average community line. With great variation in wave form performance for the same autotransformer settings, the resultant peak kilovoltages may be high or low in relation to the calibrated values, depending upon whether the wave form of the current supplied more closely simulates a pure sine wave or whether it is further distorted from it as compared with that of a community line.

c. The instructions pertaining to fuel, lubrication, and general care of this item will be found on the inside of the lid of its special chest. These should be followed closely.

21. Portable grid unit.—Item No. 96070 has been designed particularly for use in the emergency receiving ward of the evacuation hospital or of the general hospital. It is a wafer type of grid supported in an adjustable housing. This housing is adaptable to the horizontal member of the table. A patient can be carried in on a litter and the litter placed upon the table ends so that roentgenography can be accomplished without moving or disturbing the patient. The wafer grid itself can be removed and used in immediate contact with the cassette at the bedside. When the entire unit is used with the table (see fig. 20), both the grid and the cassette (contained in a standard cassette tray immediately beneath the grid) can be adjusted to one or another level, depending upon the degree of sag in one or another portion of the litter. It is advisable to raise the grid and film until it rests just beneath the sag of the litter. The wafer grid is contained in a frame 17 inches square. It can be slid into position so that the lead strips of the grid are directed

either longitudinally or transversely in relation to the body of the patient. The lead strips of this grid are unusually thin. There are 55 strips per inch width of the grid itself—thus, even though it is a stationary type, grid marks are inconspicuous. The lead strips

FIGURE 15.—Gasoline electrical generator.

are focused, their spacing being such as to provide for a true centering (grid radius) at 36 inches. However, the focal film distance may be reduced to as little as 28 inches or it may be increased to as much as 45 inches without an appreciable cut-off. The grid ratio

is 5 to 1. Because of the fact that the lead strips are focused, it is important that the top side of the grid be placed toward the patient and X-ray tube (that is, the opposite side toward the film). For a 10-centimeter thickness of part it is necessary merely to increase the milliampere-second factor to twice that required if it were not used (whereas with moving grids—"Potter Bucky" diaphragms—approximately three times the milliampere-seconds are required for this grid ratio).

22. X-ray machine unit. *a.* Item No. 96085 is intended for all types of hospital installations. It may be packed in three field chests. Two of these chests are modified Medical Department field chests; the other one is of special construction for accommodation of the high-tension and filament transformers. The X-ray tube in its housing may be packed by setting it in a nest supported by eight springs which are attached to the inside corners of a compartment contained in one of the Medical Department field chests. In addition, this particular chest accommodates a drum for packing the two shockproof cables, as well as smaller items such as the four filters (to be used in roentgenotherapy) and the several aperture diaphragms. This chest has a gable type of superstructure which has been added in order to emphasize that the chest should be placed on end during transit. This is important in order to provide the greatest protection to the X-ray tube. The second standard Medical Department field chest is modified for accommodations of the control unit, the interconnecting cables, the timer, and the foot switch. A lead apron, a pair of lead-impregnated gloves, and a pair of goggles can be accommodated in this chest.

b. This unit has been designed to operate on line voltages between 100 and 130, with 60-cycle, single-phase, alternating current. In terms of milliamperage, its maximum capacity is 30. The construction of the high-tension transformer is such as to tolerate 60 milliamperes but the design of the autotransformer prohibits this. The reserve capacity has been provided in order to obtain the desirable minimal inverse voltage. Regardless of the fact that this unit is self-rectified, the inverse voltage exceeds the useful voltage by less than 10 kvp—a most important feature.

c. In conjunction with the X-ray table unit (item No. 96145) or the mobile X-ray chassis (item No. 96090), this X-ray machine unit is adaptable nine ways:

(1) Horizontal fluoroscopy.

(2) Foreign body localization by means of a rapid fluoroscopic method (see sec. IV).

FIGURE 16.—Item No. 96085 in field chest.

(3) Sitting fluoroscopy.

(4) Standing fluoroscopy, to the extent of accommodating routine chest studies and also gastro-intestinal studies.

(5) Horizontal roentgenography, using focal-film distances from 25 to 40 inches.

(6) Six-foot vertical chest studies.

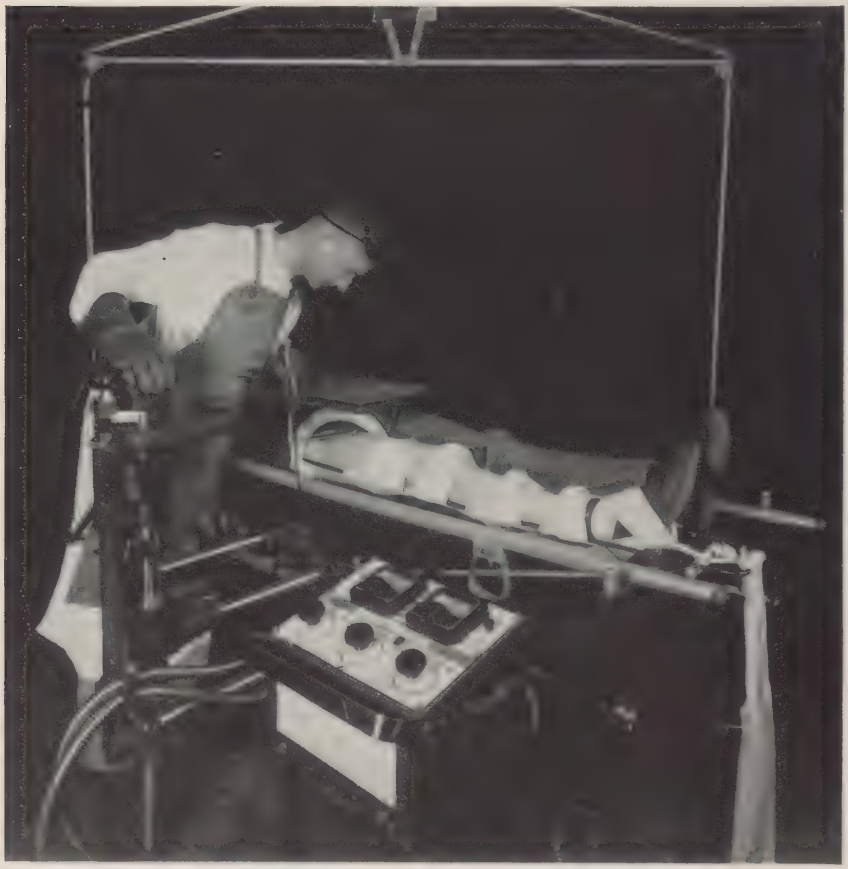


FIGURE 17.—Foreign body localization, item No. 96085 being adapted to item No. 96145 within tent (item No. 96175).

(7) Six-foot horizontal chest studies, the patient lying on the litter upon the floor.

(8) Ordinary bedside work in the wards, by means of mounting the component parts of the X-ray machine upon a mobile chassis.

(9) Superficial roentgenotherapy, to the extent of milliamperage capacities of 4 and kilovoltage potentials up to 100.

d. Precautions and general instructions are inscribed on the top of the control. Information is contained in the instruction manual as to packing and assembling the unit. This manual will be found in the tool compartment contained in the base portion of the control. Similar information is also provided by an instruction placard which

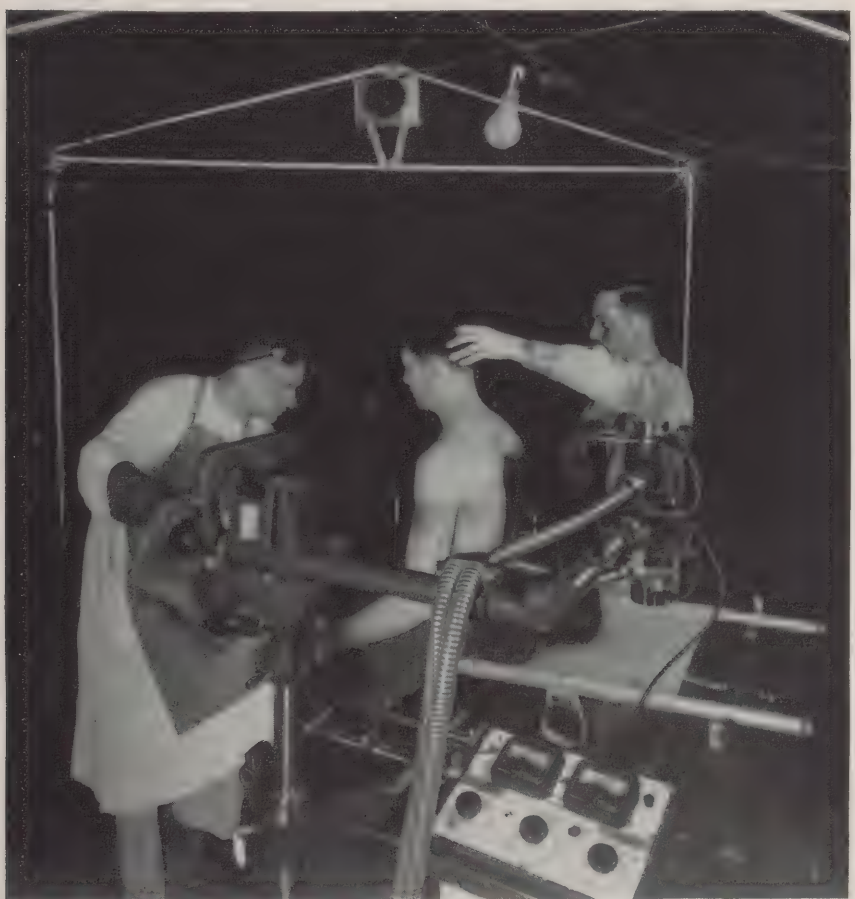


FIGURE 18.—Item No. 96085 assembled with item No. 96145 and in position for sitting fluoroscopy.

is located on the inside of the lid of the two modified Medical Department field chests.

23. Mobile chassis unit.—*a.* Item No. 96090 has been designed to convert item No. 96085 into a mobile unit for use in the wards and at the bedside. It should be of service in the hospitalization section of the mobile surgical hospital, in the evacuation hospital.

the general hospital, and the station hospital. In times of peace it is packed in a single Medical Department field chest.

b. In wartime, in addition to the wheeled pedestal and vertical column, this item will include an extra tube unit and an extra pair of shockproof cables. With such, a second chest will be included. This second chest will be identical with that described for accommodating the X-ray tube and shockproof cables in the case of the X-ray machine unit (item No. 96085). In the theater of operations,

FIGURE 19.—Item No. 96085 assembled with item No. 96145 and in position for standing fluoroscopy.

where replacements of tube units would be a difficult problem, this item will thus provide a spare tube. Otherwise, a spare tube will not be carried forward. Moreover, during wartime, this arrangement provides for an easy change-over of the X-ray machine unit from a coordinating component in connection with the X-ray table unit (item No. 96145) to that of a bedside unit. Having the X-ray

tube and shockproof cables mounted onto the mobile chassis, it is merely necessary to disconnect the shockproof cables of the table unit; to place the transformer chest into the well of the pedestal; to mount the control unit onto the transformer chest; and then to connect the shockproof cables of the chassis tube unit, without having to remove the tube unit or cables which were attached to the table unit. Particularly, where superficial X-ray therapy is to be given to ward patients, it becomes practical to accomplish the rounds in the

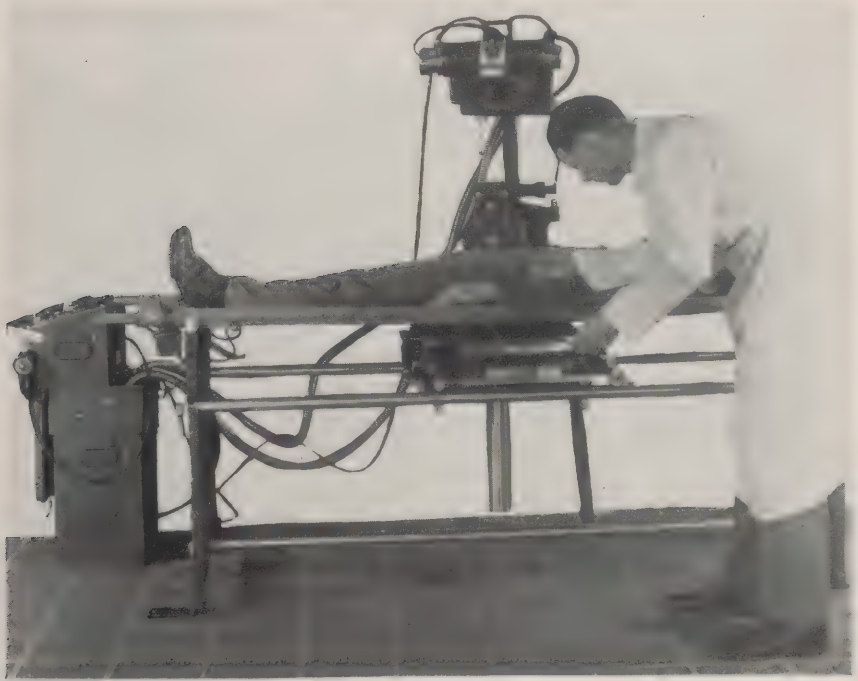


FIGURE 20.—Item No. 96085 assembled with item No. 96145 and item No. 96070—the adaptation for routine roentgenography.

ward once or twice daily and to wheel the bedside unit back to the fluoroscopic compartment, and there simply to detach the cable connections of the chassis tube and to connect the table connections of the table tube unit, in order to proceed with fluoroscopy and/or roentgenography.

24. Film-processing unit.—*a.* Item No. 96115 has been developed for use in any type of hospital installation. It has been designed as two sections: a master chemical section, and an auxiliary wash section. When using the master chemical section alone, 30 to 50 large films (depending upon the availability of community

plumbing connections and the temperature of the community water) can be accommodated within an 8-hour period. With the addition of the auxiliary wash section, these accommodations are increased to 200 or more such films. Thus it is believed that the master chemical section alone is practical for smaller station hospitals, for many corps area hospitals in times of peace, and for evacuation hospitals in the theater of operations. With the addition of the auxiliary wash

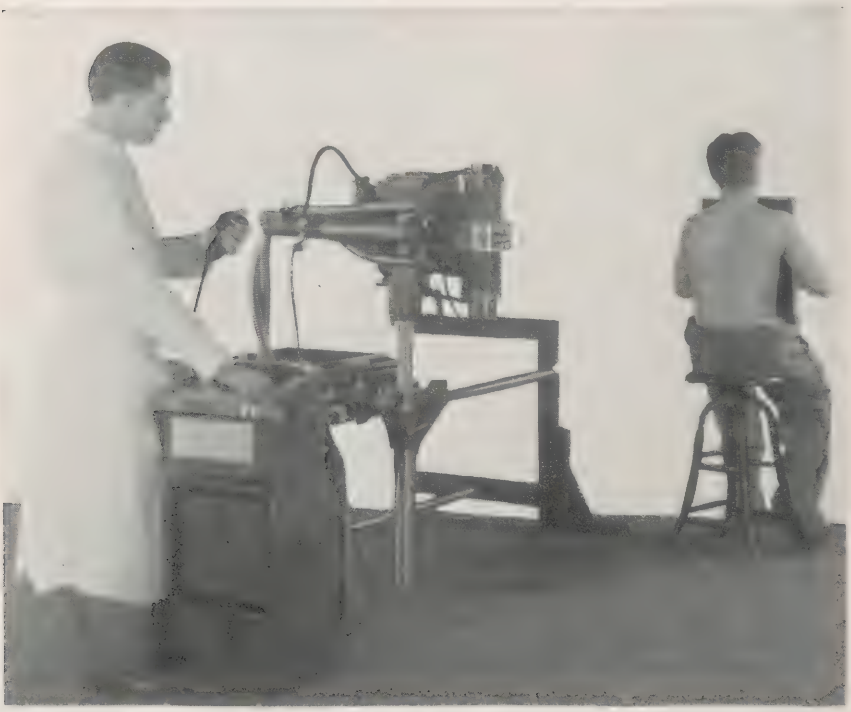


FIGURE 21.—Item No. 96085 assembled with item No. 96145—adapted for 6-foot vertical chest studies.

section, the unit is considered practical for large station hospitals, for larger corps area hospitals, and for general hospitals as well as induction centers. In a few such locations, it may be necessary to have two such complete installations.

b. The master chemical section consists of a tank compartment and a pedestal or base compartment. The tank compartment has a volume capacity of approximately 50 gallons. Three-gallon, 6-gallon, or 10-gallon insert tanks may be accommodated in it. Ordinarily, when this section is to be used alone, the insert tanks should be of 3-gallon (for developer) and 6-gallon (for the fixing bath) capacities. Two 10-

gallon insert tanks for developer may be used when the auxiliary wash section is adapted. The pedestal or base compartment contains a water-circulator unit, a refrigerator unit, a heating unit, a mixing chamber, and a thermostatic regulator. The unit is assembled by simply setting the tank compartment upon the pedestal compartment and connecting three water couplings, which can be connected without the need of tools. After adding water and making the electrical connections, the processing section is ready for use. The electrical supply should be 60-cycle, single-phase. It might be provided by community supply lines or by means of a portable gasoline electrical generator unit such as item No. 96060, though the precise regulation of that

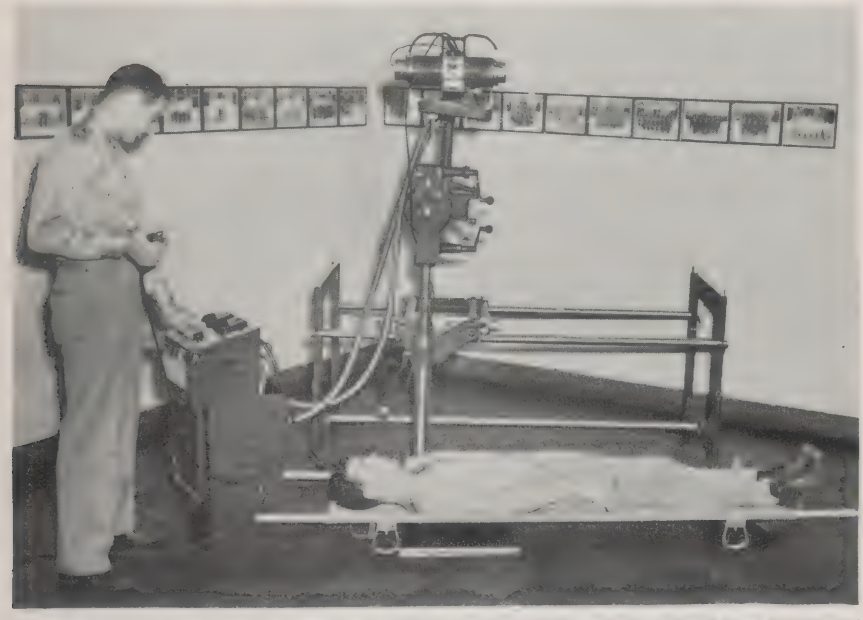


FIGURE 22.—Item No. 96085 assembled with item No. 96145 adapted for 6-foot horizontal chest studies.

particular generator is not required. When the water-circulator pump alone is operating, the electrical load is approximately 100 watts; when the cooling unit is operating with the circulator, the load is increased to approximately 700 watts, while with the heater unit it amounts to approximately 400 watts. It was not possible to obtain dual regulator switches at the time when the first of these units were constructed. Therefore, their function is such that either the refrigerator unit or the heater unit operates at all times. To counteract this adverse feature, a triple switch was incorporated in a second

FIGURE 23.—Item No. 96085 assembled with item No. 96090—the adaptation as in mobile X ray machine unit. (Note position of shockproof cables serving to counteract sharp angulations and kinkings.)

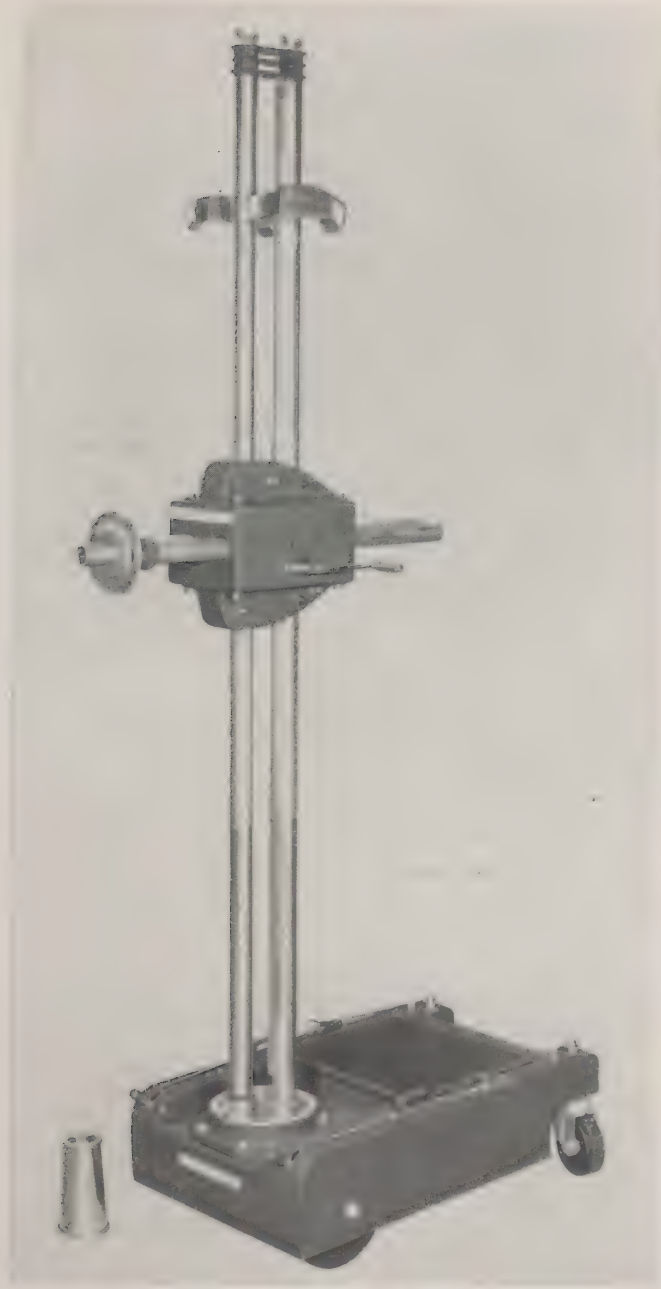


FIGURE 24.—Item No. 96090.

group. This triple switch is located in the upper right-hand corner of the front of the pedestal compartment. One switch is intended to open the entire electrical circuits; a second switch controls the heater unit alone and should serve in warm weather to prevent heating when the temperature of the water bath is reduced to 62° F.; the third switch is intended to open the refrigerator circuit alone and should serve in cold weather to prevent cooling of the wash water after bringing the temperature to 68° F. The refrigeration unit has a capacity of 4,000 Btu per hour. The heating unit has a capacity of 3,000 Btu per hour. These limitations must be respected with consideration as to the volume of water which might be allowed to flow through the unit, in the case of community water connections. If the temperature of the community water supply is excessive—above 90° F. or below 40° F. (as can be expected in climates of extreme temperatures and where the piping is close to the surface of the ground)—the rate of fresh water supply must be more limited than where the temperatures are within the ideal range of 60° to 70° F. For these reasons a calibrated inflow valve has been provided. This will be found in the upper right anterior corner of the pedestal compartment. The calibrated values represent 50 percent of the maximum water pressure estimates. Openings are indicated for occasions of various temperatures of the community water. It is the responsibility of the roentgenologist to adjust this valve in accordance with the conditions of the day. The temperature of the community water might be checked by drawing water from any spigot though this should not be necessary. It should be practical merely to note whether the heating or cooling unit can accommodate the volumes admitted. The water pump can accommodate only 20 to 25 gallons per hour. In case of inflow at a rate greater than this, recirculation of the water is opposed and the incoming water will flow into the master tank both by way of the normal inflow stem and also by way of the circulating standpipe, thereby completely inhibiting recirculation and effective heating or cooling of the wash water.

c. The auxiliary wash section also consists of two compartments: a tank compartment which is identical in dimensions with those of the master chemical tank described above, and a pedestal compartment. The tank compartment contains two baffles to provide for a cascade type of washing, as shown in figure 26. The pedestal compartment contains a precooling system. It will be noted that separate inflow valves are provided for the auxiliary wash tank and the master chemical tank. These provide for individual rates of water flow through the two tanks. The temperature of the water in the

auxiliary wash tank is regulated merely by the temperature exchange from the water overflow of the master chemical tank. This is practical because the temperature of the wash water may be as low as 40° F. or as high as 80° F.—not necessarily within the temperature range of 60° to 70° as required for the chemical solutions. Circulation and

FIGURE 25.—Item No. 96115.

volume of fresh water flow are the more important requirements as far as the wash section is concerned.

d. Both sections of the processing unit are composed of two compartments. This provision is for the sake of portability, making the unit practical both for peacetime installations and for use in the field. In case of aerial attack it can be carried in parts to a location where activities will be relatively safe. The heating and cooling

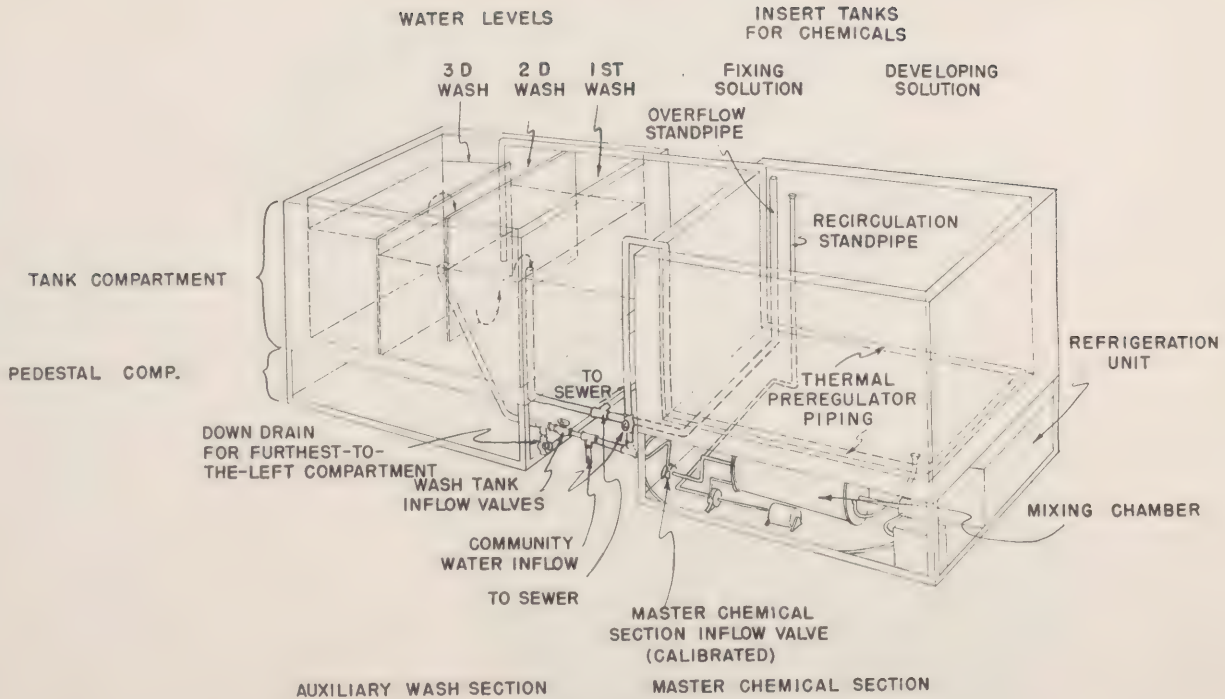


FIGURE 26.—Processing unit.

units as well as the precooler are self-contained. No special servicing is required after assembly. All connections can be made by hand.

25. X-ray table unit.—*a.* Item No. 96145 is an emergency fluoroscopic and roentgenographic table unit. It is considered practical for usage in any type of hospital installation. It is anticipated that in the mobile surgical hospital it will be set up for fluoroscopic work. In the evacuation hospital it will likely be adapted both for fluoroscopy and roentgenography. This may also pertain to the station hospital. In the general hospital it will probably serve, especially in the admitting ward, for both of these functions. It is issued in field chests or shipped in crates. As packed in chests (for duty in the combat zone), all of the components can be accommodated in two special field chests.

b. Essentially, this unit is composed of two fabricated steel end-pieces, three rails (each composed of three sections), a horizontal carriage, and a C-shaped supporting arm for accommodation of the X-ray tube unit and also of the fluoroscopic screen. These component parts and their assembly are shown in figure 28.

c. Detailed instructions covering the packing arrangement of these parts in the field chest and the means of assembly of the unit are given in the pamphlet which accompanies each unit, and also in instruction sheets which can be found on the side of the lid in the field chests. The reinforcing bolts used with the rails should be clamped tightly when assembling the table chassis. Otherwise, it is important that all clamps and boltings be tightened with finger pressure rather than with hand or arm strength. Engraved captions can be found in various locations on the C-shaped member as well as on the horizontal carriage. It is important to heed these captions, particularly the ones pertaining to releasing the clamps for fixation of the telescoping vertical member of the C-shaped arm. Two fixation clamps have been provided for this member. One of these clamps resists rotation of the telescopic portion while the other resists vertical movement of it. Unless these clamps are released before attempting either of the movements, they will soon become unserviceable. Their reinforcement is important only during foreign body localizations.

d. The C-shaped arm may be adjusted in several ways (figs. 18 to 22, incl.):

(1) The X-ray tube and fluoroscopic screen may be positioned so as to provide for horizontal fluoroscopy, with an allowance of vertical shifting through a range of 16 inches.

(2) They may be positioned so as to provide for vertical fluoroscopy, the patient being in the sitting position.

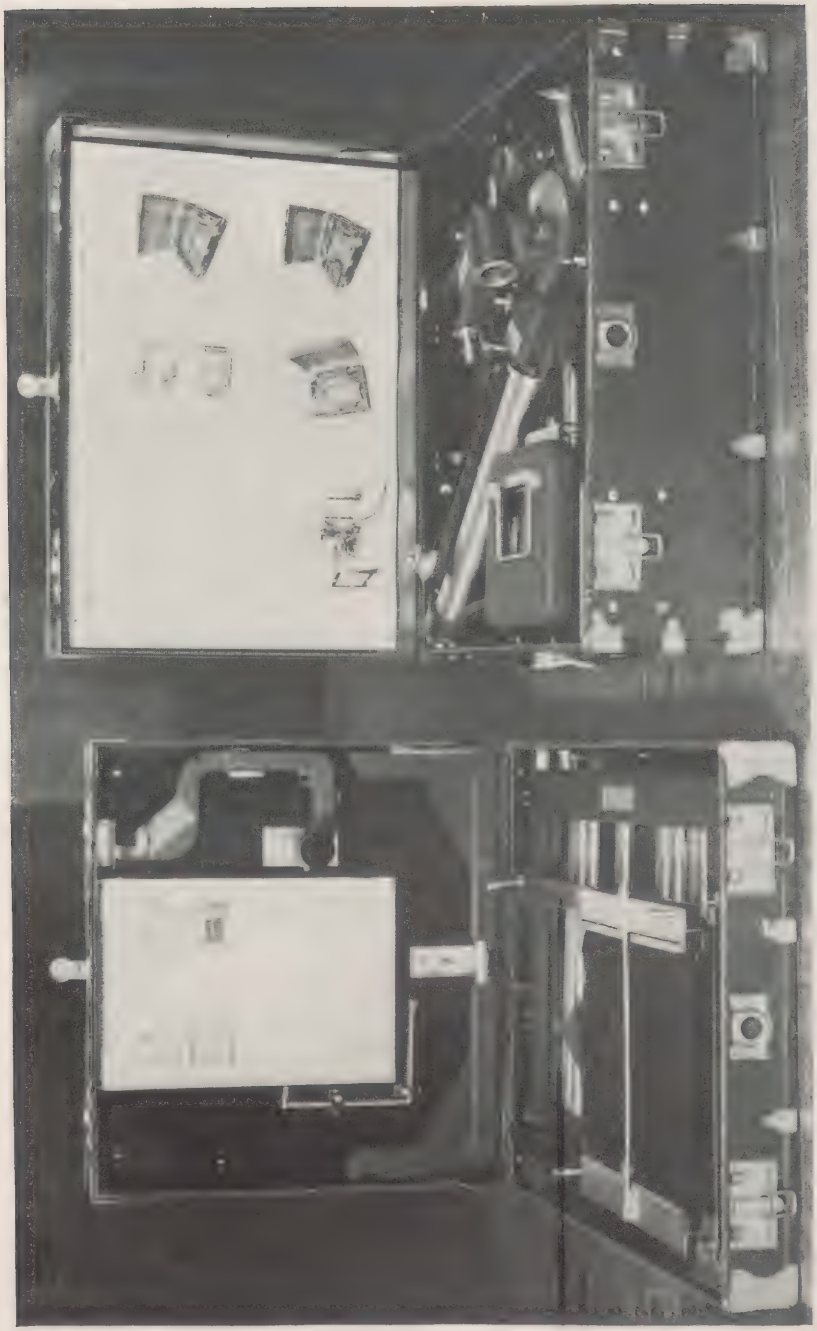


FIGURE 27.—Item No. 96145 packed in field chests.

(3) They may be positioned to one end of the table chassis so as to provide for standing fluoroscopy.

(4) The tube housing itself may be rotated to a position so as to provide for chest studies with focal-film distances as great or greater than 6 feet.

(5) In the position for conventional horizontal roentgenography, the tube housing may be raised or lowered so as to provide focal-film distances varying from 29 inches to as much as 45 inches, the

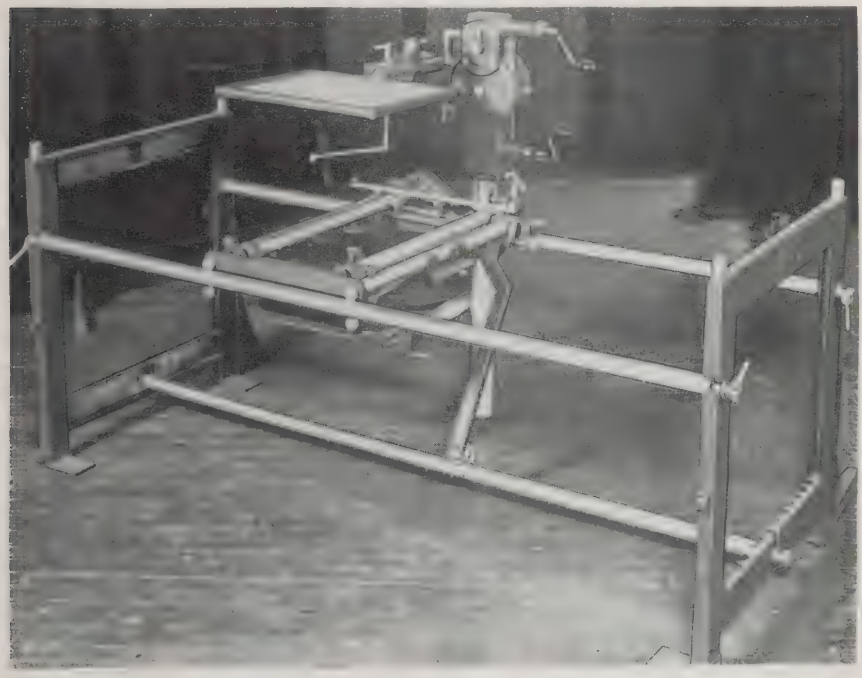


FIGURE 28.—Item No. 96145 assembled. (C-shaped member in position for horizontal fluoroscopy and foreign body localization.)

patient lying on a litter at the table-top level (in which case the portable grid unit (item No. 96070) may be used or the cassette placed immediately beneath the patient, whereupon the focal-film distance may be reduced to any desired minimum).

(6) The X-ray tube may be rotated in the horizontal plane so as to provide for chest studies of focal-film distances as great as 6 feet, the patient lying upon a litter placed upon the floor.

c. As described in section IV, two simple auxiliary parts are provided with this unit for adaptation of it to a simple fluoroscopic method of foreign body localization.

26. Darkroom tent.—*a.* Item No. 96175 has been designed for usage particularly at the mobile surgical hospitals where it is expected that it will be needed both with the mobile operating section and with the hospitalization section. Its design is such that it can be erected indoors in any room 8 by 10 feet in area and 8 feet in height (as well as within a tent or dugout) or by itself, in the open. It is therefore quickly adaptable for use in a temporary building or

FIGURE 29.—Item No. 96175, the adjustable inner curtain set forward with auxiliary drapes in position for providing largest available space as needed in fluoroscopy.

any building taken over for service as an evacuation hospital. It may even serve a purpose at a general hospital, though at this installation it is more likely that substantial darkroom construction will be had. Its design includes a two-way adaptation for fluoroscopy and/or for film processing. It provides for a quick change-over where lightproof conditions are essential. When erected on the outside, very sturdy support of it is available by means of weight-

ing its overlength apron (which extends from the ground extremities of its siding). Additional support may be provided by utilizing auxiliary guy ropes. The guy ropes are not actually included with this item but eyelets have been provided in eaves which extend from the top sides of the tent. It should not be necessary to use these guy rope supports when the tent is erected within another tent or within a room or dugout.

FIGURE 30.—Item No. 96175. the adjustable inner curtain set back with auxiliary drapes extended so as to provide the labyrinth as needed when the tent is to be used for film processing.

b. Detailed instructions as to assembly of this tent are appended to the inside of the lid of the chest which accommodates the frame support of the tent. As indicated, assembly of the roof frame should first be accomplished, the outer tentage being placed upon this frame so that the end and sides of it are thrown uppermost. The vertical members are then adjusted to each of the four corners so that they project toward the center of the area covered by the tent. The roof frame should then be elevated by lifting each of the four vertical members. The lower horizontal members should then be fixed and the tiller rope attachments applied and tightened. The sides of

the outer tentage should then be lowered and the inner curtain and auxiliary drapes adjusted. The fan for forced ventilation should then be installed in the posterior end gable. This should be inclosed by the zipper to provide for light tightness. When used for fluoroscopy, the inner curtain should be set forward (the auxiliary drapes being folded), and the zipper of this curtain should be opened so that with the door drapes extended, it will be possible to enter the passageway head first without lifting the drapes. For film processing, the inner curtain should be set back (20 inches) and the auxiliary drapes should be extended so as to provide a labyrinth. These two adaptations are shown in figures 29 and 30.

Section IV

FOREIGN BODY LOCALIZATION[1]

27. General. —The X-ray table has been designed to provide for a rapid fluoroscopic method of localization of X-ray opaque bodies. The method is based upon triangulation principles, utilizing large dimensional relations. This particular method has been selected because of several favorable features:

a. Simplicity of the auxiliary parts required.

b. Ease of making the alinements. Instead of wires or diaphragm cut-off to be visualized through the density of an overlying part, clearly discernible intersecting lines on the fluoroscopic screen are used.

c. Short time requirement for localization of any one foreign body—less than 1 minute.

d. Minimal X-ray exposure imposed upon the patient—no greater than 150 milliampere-seconds with a focal-skin distance of 12 inches or more (with negligible secondary radiation directed toward the examiner and assistants).

e. Accuracy of localization. This method is limited only by technical discrepancies on the part of the operator (provided the reading

[1] As provided with X-ray field table unit, item No. 96145.

level is properly adjusted before making the calculations (see par. 29)).

f. Provision for positioning of the fluoroscopic screen either in contact with the skin surface or at a distance above it, thereby permitting clearance for manipulation.

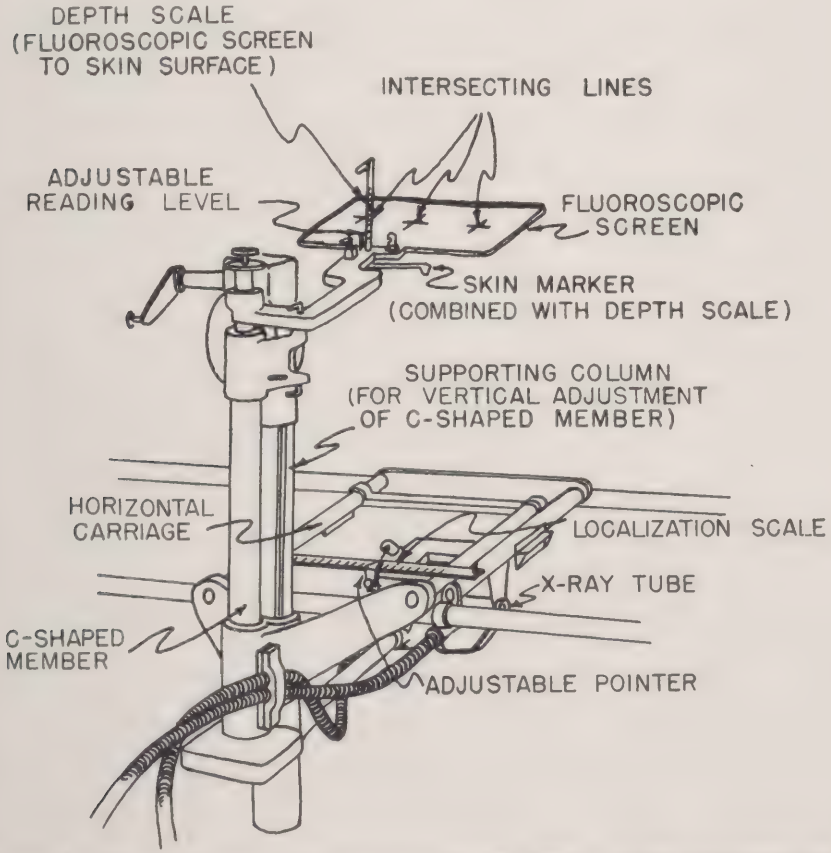


FIGURE 31. Design and construction features of item No. 96145, providing for foreign body localization.

g. Convenience in marking of the skin surface. This can be accomplished with true alinement relations but without resorting to the application of the skin marker through an opening in the fluoroscopic screen.

28. Working parts.—*a*. To provide for this method of localization, only two auxiliary parts are required. Neither of these is easily detachable nor small enough to be easily lost. These parts are—

(1) Combination depth scale and skin marker which should be mounted on the supporting arm of the fluoroscopic screen.

(2) Localization scale and its adjustable pointer which are attached to the horizontal carriage.

b. The focal spot of the X-ray tube is located at a distance of 66 centimeters (plus or minus 1.5 centimeters) beneath the center of the fluoroscopic screen. There are inscribed upon the fluoroscopic screen three sets of intersecting lines. One of these sets is located in the center of the screen; another, 11 centimeters beyond the central set toward one end of the screen; while the third set is located 11 centimeters in the opposite direction from the central set. Thus the spacing between the outer intersecting lines is 22 centimeters or one-third of the focal-screen distance (except for minor variations in the latter).

29. Preliminary testings.—*a.* An adjustable reading level has been provided in connection with the depth scale. This reading level is incorporated for accuracy and to compensate for variations in the position of the focal spot with considerations of one or another X-ray tube—variations which might produce plus or minus changes in the focal-screen distance of as much as 1.5 centimeters. As the equipment is shipped from the factory, the reading level is positioned properly in relation to the average X-ray tube assembly. However, in order to be certain that this level has not shifted, as well as to compensate for parallax, it is important to conduct preliminary testings of localization, making use of the depth phantom which is carried in the tool compartment of the larger of the two field chests (in which the table unit is packed). This preliminary testing should be conducted in the following manner:

(1) Place a board across the litter (table top) to provide for a rigid surface (comparable to the patient). On this board, 4 or 5 centimeters beneath the fluoroscopic screen, place the depth phantom in position so that the lead letters are on planes which respectively represent their distances below the top surface of the phantom as shown in figure 32.

(2) Aline one conspicuous point of the number "12" to either of the two outer intersecting lines of the fluoroscopic screen.

(3) Adjust the pointer on the horizontal rail and clamp it to a position so that it points to "12" on the localization scale, this adjustment being made to the "12" on the end of the localization scale coinciding with that of the intersecting lines selected for the alinement of the lead number "12" of the depth phantom.

(4) Shift the tube and the screen in the opposite direction until the very same point of the lead number "12" of the depth phantom is alined to the opposite outer intersecting lines of the fluoroscopic screen.

(5) Read the new value indicated on the localization scale by the pointer on the horizontal carriage.

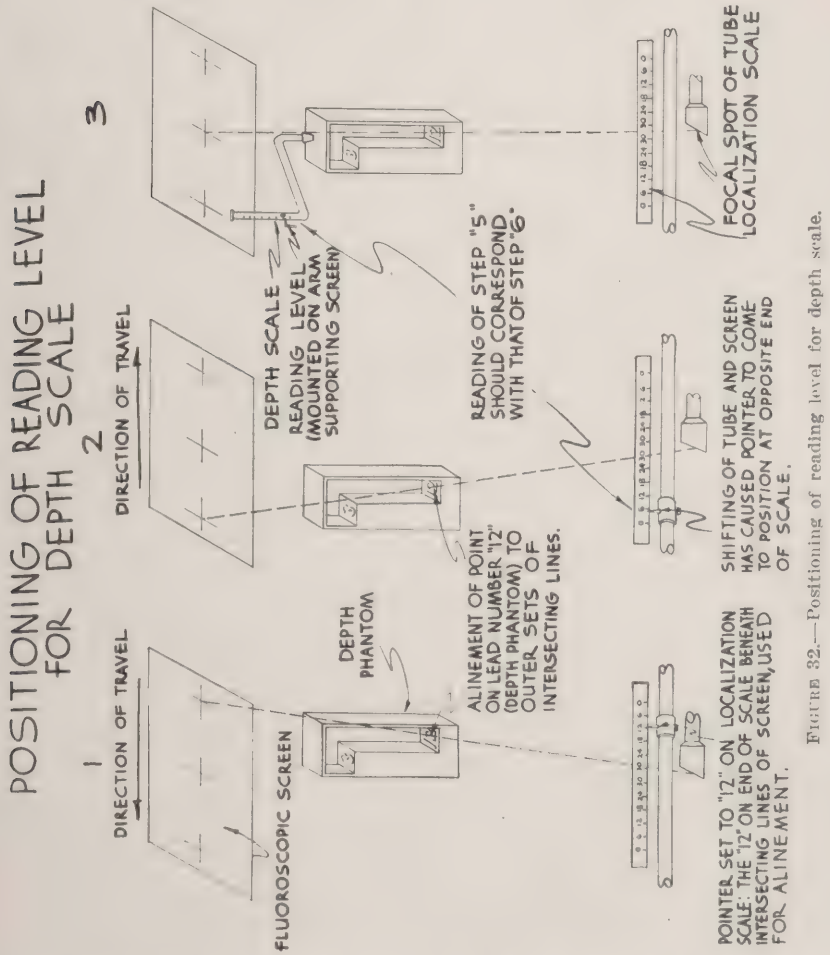


FIGURE 32.—Positioning of reading level for depth scale.

(6) Shift the fluoroscopic screen and X-ray tube to a position for alinement of the lead number "12" (of the phantom) to the central set of intersecting lines. Superimpose the skin marker into this alinement and lower the depth scale until the skin marker rests upon the top surface of the depth phantom. Read the value indicated on

the depth scale—the indicated depth of the top of the phantom (substituting for the skin surface) beneath the fluoroscopic screen.

(7) In case the depth scale value indicated in (6) above does not coincide with the value indicated in (5) above, release the setscrew

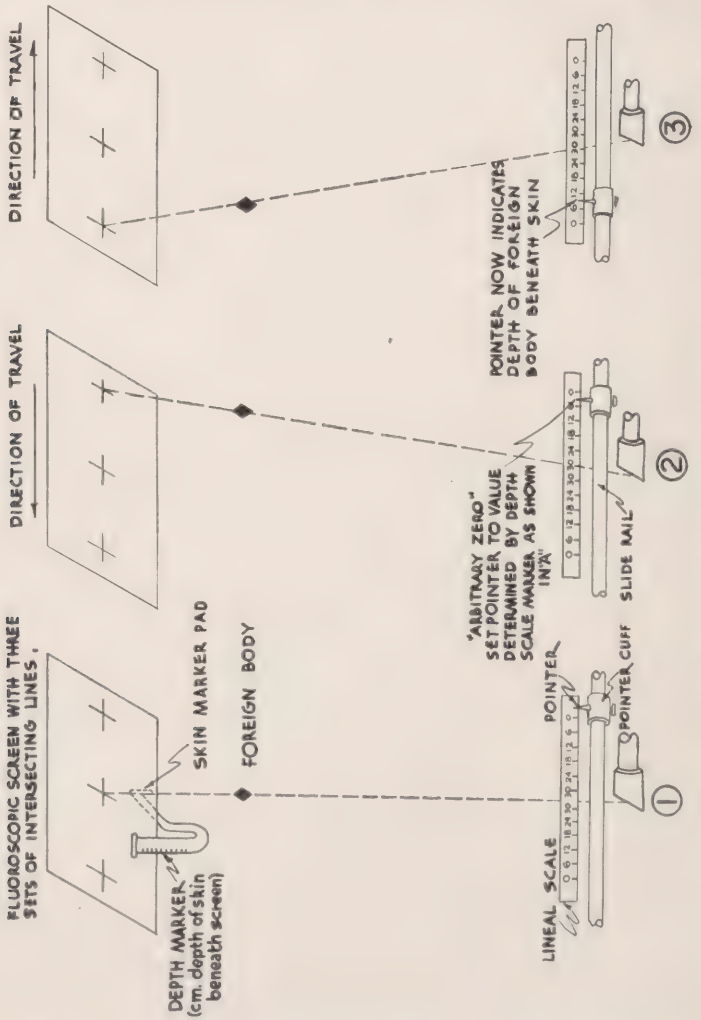


FIGURE 33.—Procedure diagram for localization.

used with the reading level (as shown in fig. 31) and readjust the reading level to the value indicated in (5) above.

b. Once having set this reading level in this manner, it should not be necessary to readjust it, unless there are extreme changes in weather conditions and provided the X-ray tube is not changed.

The setscrew should be securely clamped for fixation of the reading level. Should there be extreme changes in weather conditions so that the bakelite support of the fluoroscopic screen becomes buckled or changes from a buckled state to that of a true plane, a recheck as above described should be accomplished. Such changes in the level of the fluoroscopic screen are likely to alter the degree of parallax and, unless the reading level is readjusted, errors to the extent of several millimeters may be incurred. It is important that several testings be conducted in order to establish the correct position for this reading level. It is recommended that these testings be made with the use of the "3" centimeter level as well as with the use of the "12" centimeter level and that these be checked for various positions of the fluoroscopic screen (that is, obtained by shifting the position of the fluoroscopic screen and the tube in the vertical plane).

c. This preliminary testing procedure is the opposite of the actual procedure concerned with localization for foreign bodies.

30. Localization procedure.—*a.* Having accomplished a trustworthy adjustment of the reading level for the depth marker scale, the actual steps of localization should also be practiced with the use of the depth phantom. The procedure is as follows:

(1) Check fixation locks on C-shaped member; secure alinement of focal spot to center of fluoroscopic screen (fig. 31).

(2) Aline a prominence on foreign body to intersection of central intersecting lines.

(3) Dampen skin marker pad with tincture of iodine or ink and adjust it to this alinement (foreign body and intersection of central intersecting lines); lower skin marker pad until it rests on the skin (or top of the depth phantom), thereby marking it.

(4) Read distance between fluoroscopic screen and skin (or top of the depth phantom) by way of scale on depth marker (fig. 33①).

(5) Shift tube and fluoroscopic screen so as to aline the same prominence of the foreign body, as considered in (2) above, to the intersection of either of the outer intersecting lines (fig. 33②).

(6) Slide localization scale and adjust pointer to the centimeter value coinciding with the centimeter distance between the fluoroscopic screen and the skin as measured in above—this is the arbitrary zero. Clamp cuff for fixation of pointer to side rail of table.

(7) Slide X-ray tube and fluoroscopic screen in direction opposite to that used in (5) above, until the same prominence on the foreign body becomes alined to the intersection of the opposite outer intersecting lines (fig. 33③).

(8) Read on localization scale the depth of foreign body beneath the skin (or top surface of depth phantom).

b. Reporting of actual localizations should be accomplished on the skin surface of the patient and also by a written report, using standard forms such as W. D., M. D. Form No. 52b (Emergency Medical Tag) (fig. 34) or the medical tags, W. D., M. D. Form No. 55-series, as used in the theater of operations. On the skin surface of the patient

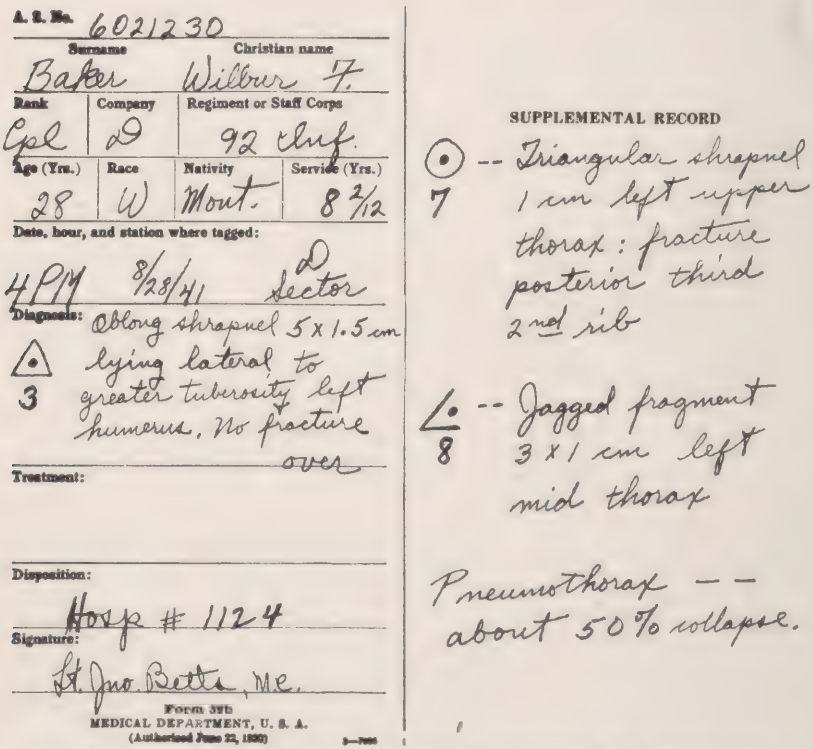


FIGURE 34.—Showing front and back of Medical Department field tag with report of localizations of foreign bodies.

a dot should be marked over the foreign body. Since several such dots might be made, either carelessly or because of there being a number of foreign bodies contained, the precise marking should individually be identified by means of an outer character such as an outer circle, square, or triangle; an intersecting line; a nearby acute, obtuse, or right angle, etc. Near such identification the depth of the foreign body should be recorded. These same characters should be used in making the written reports, in which case the depth values should be recorded

beneath the character serving to identify each foreign body. Unnecessary details should not be included, though information should be recorded as to the position of the patient when the localization was accomplished, the approximate size and character of the foreign body, its relations to anatomical landmarks, and the apparent condition of the tissues (particularly the skeleton).

31. Geometric analysis of method.—Geometrically, the principles concerned with this method of foreign body localization might be described as follows:

a. *AB* equals the spacing between the outer intersecting lines; it is equal to 22 centimeters.

b. *FS* equals the focal-screen distance (focal spot to intersection of central intersecting lines); it is equal to three times *AB*, or 66 centimeters (plus or minus minor deviations in the position of the focal spot).

c. If a foreign body were located at *S* (that is, just beneath the intersection of the central intersecting lines), for alinements of it to the intersection of the outer intersecting lines at *A* and then at *B*, the X-ray tube would have to be moved with the fluoroscopic screen for distances equal to *SB* and then *SA*, respectively, in order to provide for alinements of the foreign body to the intersections of the lines at *A* and then at *B*. On the localization scale, the distances of such movements would be represented by *FC* and *FD*, since the gradations on this scale are limited to a total range of 22 centimeters (same as the spacing between the outer intersecting lines described upon the fluoroscopic screen). In the case of foreign bodies located at other levels below the plane *AB*, this same ratio relationship would hold true with respect to the distance of shifting requirement and the distance between the focal spot of the X-ray tube and the foreign body. Similar triangles are involved, and since the ratio relationship between *AB* and *FS* is as 1 to 3, for foreign bodies located at any level beneath the fluoroscopic screen and between it and the X-ray tube, the distance of shift required for similar alinements would equal one-third of the distance between the plane of the focal spot and the plane of the foreign body. Actually, the measurement between the focal spot and the foreign body is unimportant. Instead, the important measurement is that between the level of the fluoroscopic screen and the foreign body. This measurement can be estimated by calculation, not of the distance of shift required for the alinements described above, but instead by calculating on the basis of the difference between that distance and the extreme range of shifting possibility, that is, the 22 centimeters. Thus the calculation as to the depth of the foreign body

beneath the plane of the fluoroscopic screen is based upon the untraveled distance. This can be explained as follows:

FIGURE 35.—Geometric details, showing normal and abnormal focal-fluoroscopic screen distances.

(1) Since triangle EJG is similar to triangle $JH1$, the distance SJ bears the same ratio relationship to $H1$ as does JF to EG, that is, a 3 to 1 ratio.

(2) *HI* is equal to *HS* plus *SI*.

(3) *HS* equals *GD* while *SI* equals *CE*; therefore, *HI* equals *CE* plus *GD*. *CE* plus *GD* is the untraveled distance (22 centimeters minus the distance of shifting of the X-ray tube and fluoroscopic screen).

(4) The distance from the fluoroscopic screen to the skin is subtracted by making the adjustment of the pointer to an arbitrary zero as shown in figure 33② and as described in paragraph 30(6). Therefore, the reading of the untraveled distance (as indicated on the localization scale) indicates the measurement of depth of the foreign body beneath the skin level.

32. Accuracy of method.—*a.* The actual error incurred because of variations in the position of the focal spot of an X-ray tube is very small. This can be proved by geometric analysis, referring to figure 35.

(1) *Formula A.*—*EG* represents the distance of shifting required for the alinements of a foreign body at *J*, first in relation to the intersection at *A* and then at *B*.

Ideally (when the focal screen distance is exactly 66 centimeters):

$$EG/FJ=CD/FS.$$
$$EG\times FS=CD\times FJ.$$

Therefore:

$$EG=\frac{CD\times FJ}{FS}.$$

Substituting:

$$EG \text{ (distance of shifting required)}=\frac{22\times FJ}{66}.$$

(2) *Formula B.*—Plus or minus variations with respect to the position of the focal spot of the X-ray tube in relation to 66 centimeters will result in plus or minus variations in these values. These new distances might be considered as indicated by the prime values (fig. 35). Thus, the above geometric analysis is modified as follows:

$$E'G'/F'J=C'D'/F'S.$$
$$E'G'\times F'S=C'D'\times F'J.$$

Therefore:

$$E'G'=\frac{C'D'\times F'J}{F'S}.$$

Substituting.

$$E'G'=\frac{22\pm\times FJ\pm}{66\pm}.$$

b. Comparing the requirement of shifting of the tube under ideal conditions versus the requirement under abnormal conditions, these two formulas (*A* and *B*) indicate that with the expected limits in deviation in position of the focal spots of no greater than 1.5 centimenters, these conclusions (*a* and *b*) would practically be resolved to:

$$\text{Shifting distance equals } \underset{\text{Ideally}}{\frac{FJ}{3}} \text{ versus } \underset{\text{Abnormally}}{\frac{FJ \text{ plus or minus } 1.5}{3\left(\begin{smallmatrix}\pm 1.5\\ 22\end{smallmatrix}\right)}}$$

Such variations will be found to amount to no more than a few millimeters.

33. Precautionary measures.—*a.* Most important is the matter of proper positioning of the reading level for the depth scale as described above.

b. Attention should be given to the vertical column of the C-shaped member. Two clamps are provided for firm fixation of this member in order to avoid any change in relations during the shiftings. (These clamps should be released before making any vertical adjustments of the C-shaped member or before rotating it.

c. To accomplish the shiftings of the X-ray tube and fluoroscopic screen, pressure should be exerted not upon the screen itself nor its horizontal arm support, but instead, upon the fixed supporting column. (See fig. 31.)

d. It is important that the same landmark, the same point of the foreign body, be used for each phase of the alinements.

e. As nearly perpendicular viewing as possible should be performed by the examiner in making the alinements and also in reading the scales and in setting the adjustable pointer.

34. The biplane marker.—*a.* There have been some advocates of biplane fluoroscopy. Surgeons are especially prone to speak of this need. They want an indication as to the location of the foreign body with respect to two planes. Biplane fluoroscopy was not considered practical for field activities for several reasons: it would have required the use of two X-ray tubes, four shockproof cables, and two fluoroscopic screens or readjustments of the one tube and screen—a provision which would have been costly in the way of bulk, weight, expenditure, or time; small foreign bodies cannot be adequately visualized through dimensions such as the width of the chest or the trunk; where many fragments are to be localized, double markings are too likely to lead to confusion; and finally, biplane fluoroscopy would require double or more than double the X-radiation exposures upon the patient, as

compared with the exposures required for the method described above.

b. In lieu of such a provision, a biplane marker may be used. Its manipulation does not require fluorscopic visualization. It may be constructed with a horizontal leveling arm and an adjustable marker sliding on a vertical supporting arm (see fig. 36). Centimeter gradations etched upon this latter arm provide for positioning the marker at the depth level calculated by the localization procedure described above. If the horizontal leveling arm rests upon a level which is higher than the level at which the foreign body was spotted, the marker can first be used to measure the difference in these two levels; the difference (measured in centimeters) then added to the depth calculation value, thereby indicating the proper level for positioning the marker. The second marking (that is, in the vertical plane) is accomplished by

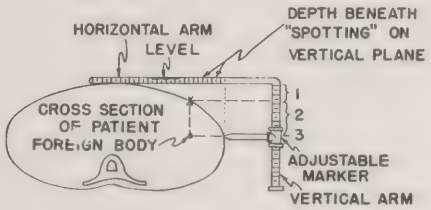


FIGURE 36.—The biplane marker.

simply sliding the horizontal arm (with the adjustable marker properly positioned) until the latter comes into contact with the skin surface. A scale on the horizontal arm serves to indicate the depth relation with respect to this new "spotting" of the foreign body.

SECTION V

LOCALIZATION OF INTRAOCULAR FOREIGN BODIES

35. General.—*a.* Localizations of foreign bodies in the eye require precision measurements and calculations with respect to the

center of the pupillary diaphragm and the wall limits of a normal eyeball. It is not practical to base measurements of these foreign bodies beneath a surface marking as provided with the routine procedure described in section IV.

b. Apparatus has been designed and equipment is commercially available for a number of different methods for accomplishing this

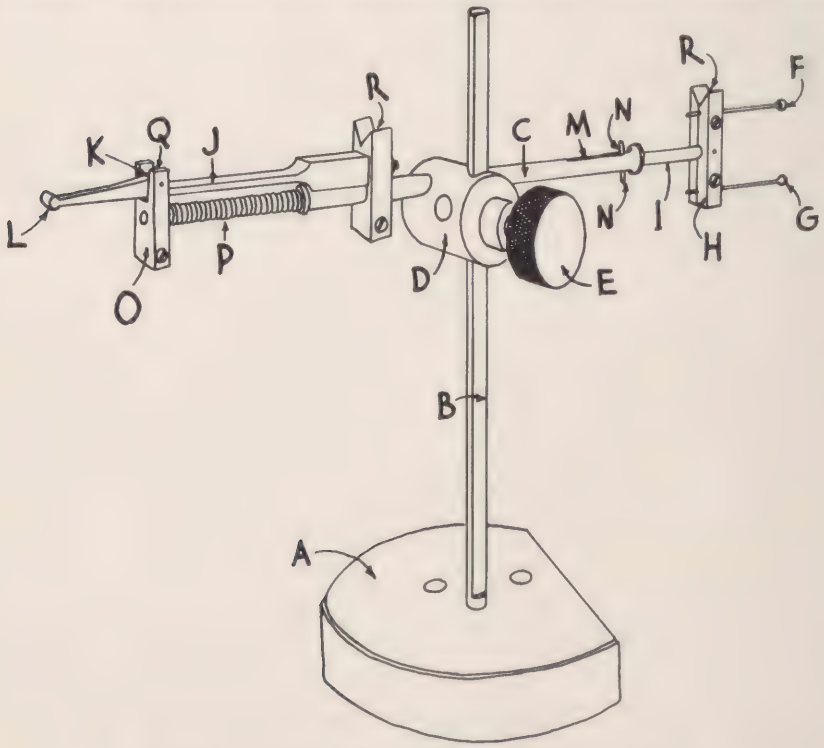


FIGURE 37.—Localizer for foreign bodies within the orbit.

work. In the United States Army, particularly with the application of standard field X-ray equipment, the "Sweet method" has seemed the most practical. It provides for calculating measurements in three different planes, does not require the use of elaborate equipment, and the technical procedure is simple. Using this method, it is not necessary to anaesthetize the eye nor to adapt orienting landmarks.

36. Apparatus required. — *a*. The localizer unit consists of the following construction features (fig. 37):

(1) A heavy metal base *A*, serving for support of the unit.

(2) A vertical supporting arm *B*, providing for adjustment and fixation of the horizontal supporting channel arm *C*.

(3) A supporting bracket *D*, having a setscrew *E*, providing for raising or lowering and fixation of the horizontal channel arm *C*.

(4) A metal ball *F* and metal cone *G*, spaced 15 millimeters apart, and supported on bracket *H* which in turn is fixed to rod *I* which moves within horizontal channel arm *C*.

(5) Spring catch *J*, having engaging notch *K* and trigger release *L*, serving for forward setting of the ball and cone and then release of

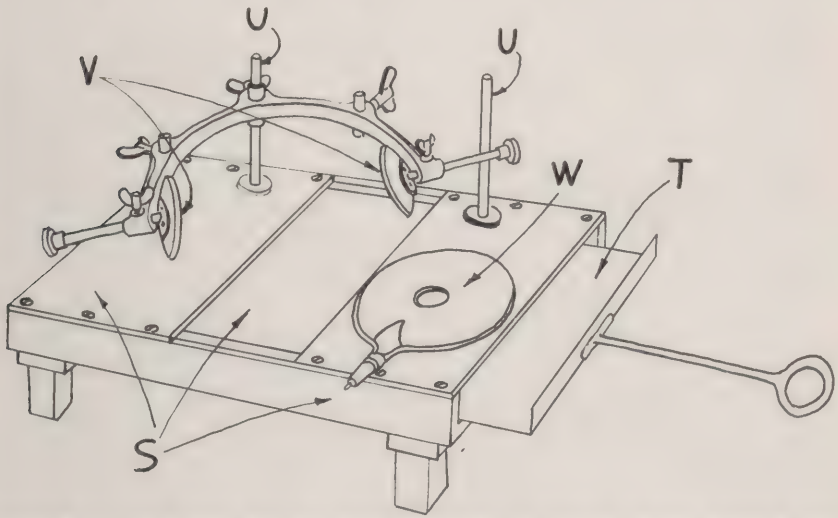


FIGURE 38.—Head support and film tunnel changer for localizer of foreign bodies within orbit.

them to the extent of exactly 1 centimeter as controlled by slot *M* in the supporting channel arm *C* and stops *N* mounted on rod *I*.

(6) Bracket *O* fixed to rod *I* serving for support of recoil spring *P* and catch *Q* for engaging notch *K*.

(7) Sighting notches *R*, serving for true positioning of the ball *F* in apposition to the center of the cornea.

b. The headrest unit consists of the following construction features (fig. 38):

(1) A special pedestal tunnel *S*, having lead protection over its upper, outer thirds so as to provide for exposure of one-half of an 8- by 10-inch film as contained in a cardboard holder and positioned in sliding film tray *T*.

(2) Vertical supporting columns *U*, serving for support of the head clamp *V*.

(3) Pneumatic ring *W*, for support of the patient's head.

37. Technical procedure.—*a.* The patient is placed on the X-ray table, lying on the same side as the eye in which a foreign body is

FIGURE 39.—Patient positioned for localization of foreign body within orbit.

thought to be contained. The pedestal tunnel of the headrest is placed beneath the head and the head is positioned so that the region

of the eyes is superimposed over the portion of the tunnel which is unprotected by lead (place pneumatic ring under head, if desired). The supporting head fixation pads are then positioned so as to fix the head to a position wherein the midsagittal plane of it is parallel to the film.

b. Place localizer on stand, ball and cone side nearest eye. Sighting through notches *R*, aline metal ball *F* to center of cornea (center of pupillary diaphragm). Fix setscrew *E*. Engage horizontal rod *I* by means of spring catch *J*, at notch *K*. Have patient close eyelid; advance localizer unit until metal ball *F* presses into the lid to an extent equivalent to the thickness of it. Release trigger *L* and allow patient to open eyelid; thereafter, instruct patient to maintain a focus onto an object at a distance and in line with sighting notches *R* and metal ball *F*. These relations are demonstrated in figure 39.

c. Aline focal spot of X-ray tube over metal ball *F* and cone *G* (focal spot, ball, and cone being alined by so-called central ray in perpendicular relation to film) and position tube at a working distance (30 inches) above film. Position film in cardboard holder in sliding film tray *T* so that one-half of it lies beneath the unprotected portion of the tunnel *S* (beneath the eye portion of the patient's head and beneath the localizer ball and cone). After providing identification, make an X-radiation exposure as for a slightly underexposed lateral paranasal sinus study, such as the following:

Distance	*Milliampere-seconds*	*Kilovoltage*
30 inches	60	75

Slide film in tray so that the unexposed portion of it is placed into position for a second exposure. Shift X-ray tube approximately 6 inches toward the feet of the patient and make a second exposure, using the same factors as previously. The resultant roentgenogram should appear as shown in figure 40.

38. Calculation procedure and development of indicating chart.—*a.* On the first of the two exposures contained on the roentgenogram the ball and cone should be superimposed, while on the second exposure the ball should be projected to a relatively high level in relation to the cone. The entire orbit of the patient should be visualized. Search should be made for one or more foreign bodies. With consideration of any one foreign body, the localization is plotted onto a special coordinate chart (fig. 41), as follows:

(1) Etch a line on the first exposure of the film through the horizontal axis of the ball and cone, thereby projecting the visual axis of the eye.

(2) Etch a second line at right angles to and intersecting this one and through the center of the outline of the foreign body.

(3) Using a small pair of dividers, set its points, one to the edge of the indicator ball and the other to the intersection of the horizontal and vertical lines just drawn. Transpose this distance

FIGURE 40.—Roentgenogram as used for localization of foreign bodies in orbit.

onto the coordinate chart shown in figure 41, as indicated at the intersection of lines *B* and *A*.

(4) Again, using dividers, set its points, one to the intersection of the horizontal and vertical etching just described, the other point to the center of the outline of the foreign body. Transpose this distance onto the coordinate chart in its proper relation to the visual axis, at *F*.

(This procedure serves to locate the foreign body at *F*, antero-posteriorly in relation to the lateral vertical plane.)

(5) Extend line *A* so as to cross over the front view of the orbit

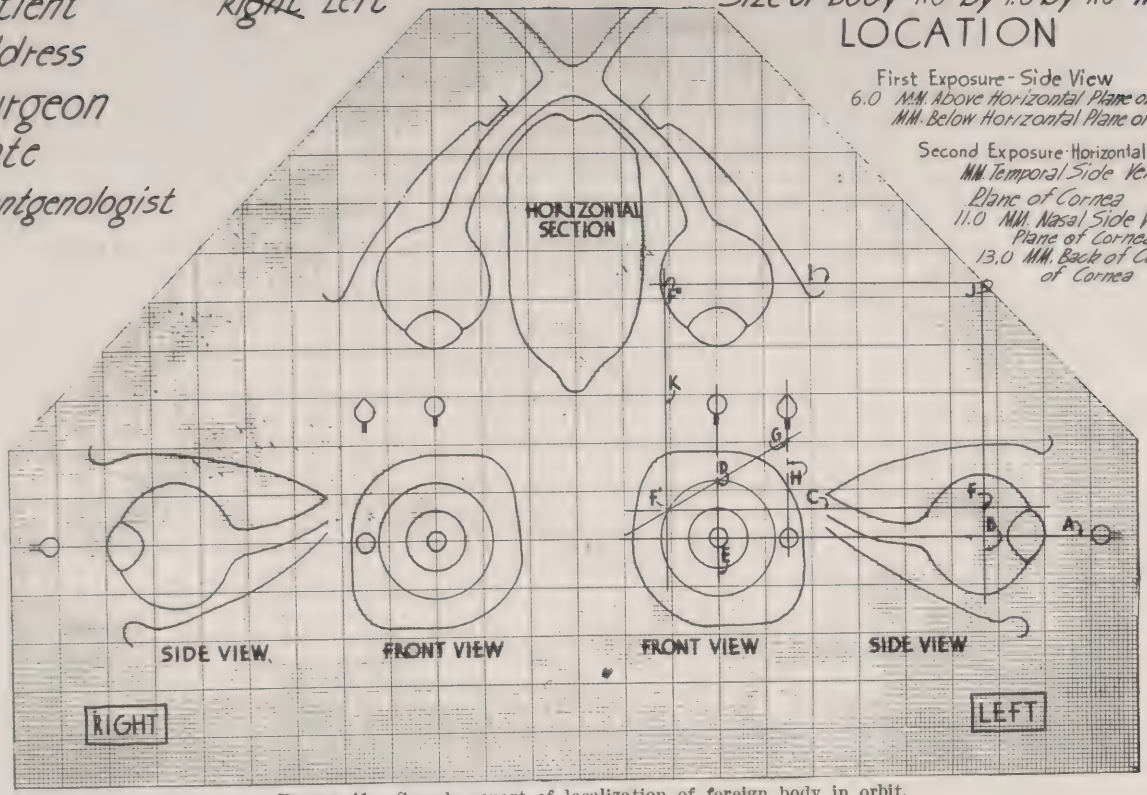


FIGURE 41.—Sample report of localization of foreign body in orbit.

(as shown on the coordinate chart) and extend line *B* to the oblique boundary of the chart.

(6) Extend a line *C* horizontally from the location of the foreign body at *F*, parallel to line *A* and across the front view on the chart.

(7) Using the second exposure of the roentgenogram, etch one line through the axis of the ball and its supporting arm and another line through the axis of the cone and its supporting arm.

(8) Etch a third line at right angles to and intersecting these two lines and through the center of the outline of the foreign body.

(9) Using the dividers, set its points, one to the center of the outline of the foreign body, the other to the intersection of the etching concerned with the ball; transpose this spacing onto coordinate chart in relation to the outline of the ball as shown by point *D* on line *E*.

(10) Again using the dividers, repeat this procedure with respect to the center of the outline of the foreign body and the intersection of the etching concerned with the cone, transposing this spacing onto the coordinate chart in relation to the outline of the cone as shown at point *G* on line *H*.

(11) Extend a line through points *G* and *D*, intersecting line *C* at *F'*.

(These transpositions serve to locate the foreign body at *F'*, laterally, in relation to the front-view vertical plane.)

(12) Extend line *I* from the intersection of line *B* and the oblique boundary of the chart at *J*, parallel to line *C*, so that this line crosses the horizontal outline of the orbit.

(13) Extend another line *K* at right angles to line *C*, from the point *F'*, so as to intersect line *I* at point *F'*.

(These extensions serve to locate the foreign body at *F'*, laterally, in relation to the horizontal plane.)

b. By merely counting the millimeter coordinate spacings, it is possible to render a report as to the location of the foreign body with respect to the central axis of the eyeball and in relation to the side view, front view, and horizontal plane. Using the chart as shown in figure 41, these measurements should be reported in the upper right corner.

39. Importance of precision in transpositions and plottings.—Extreme care should be exercised in making all transpositions. Too frequently, plottings are made so that the localizations are indicated either on the wrong eye or on the wrong side of the central axis in one or another plane. Also, all plottings may be properly accomplished but the reporting inaccurately made (that is,

with consideration of "above the horizontal plane" versus "below the horizontal plane" or "on the temporal side" versus "on the nasal side"). Such errors may lead to unnecessary extensions or duplication of surgery.

40. Identification of intraocular versus extraocular positions of foreign body. -Not infrequently, foreign bodies are found to be located in a position which raises the question as to whether they are actually contained within the eyeball or whether they might be resting in the periocular fat or even in the eyelid or the bony orbit. In such cases, it is advisable to make a two-exposure study. The headrest described above may be used and the patient may be positioned in the same manner as just described. The focal spot of the X-ray tube is alined over the center of the orbit and the X-ray tube at a working distance such as 30 inches, and two exposures are made, using factors as described above but without shifting the tube between the two exposures; instead, merely having the patient "look up" during the first exposure and "look down" during the second exposure. If there is no duplication in the outline of the foreign body or change in configuration of it, the evidence is that it is located outside of the orbit. This is a most important revelation since it may alter the course of surgery considerably.

Section VI

ROENTGEN EXAMINATIONS

41. General.—It has been estimated that at least 75 percent of early active pulmonary tuberculosis can be discovered only by X-ray examination. Statistics indicate that approximately 1 percent of the male population of military age in the United States has active pulmonary tuberculosis. The expenditures because of tuberculosis since the World War in 1918 have been so enormous (estimated as totaling

approximately $1,000,000,000), and the days lost from service have been so great in numbers (fig. 42) that The Surgeon General has seen fit to provide for an X-ray examination of the chest of every candidate before admission to the service and a repetition of this examination before discharge from the service. These X-ray examinations must serve for the identification of all active or unstable tuberculous lesions as well as other conditions of the lungs or heart which would not be expected to withstand military service or which might be used by the individual for shirking of duties or the development of pension claims. The film quality must therefore be satis-

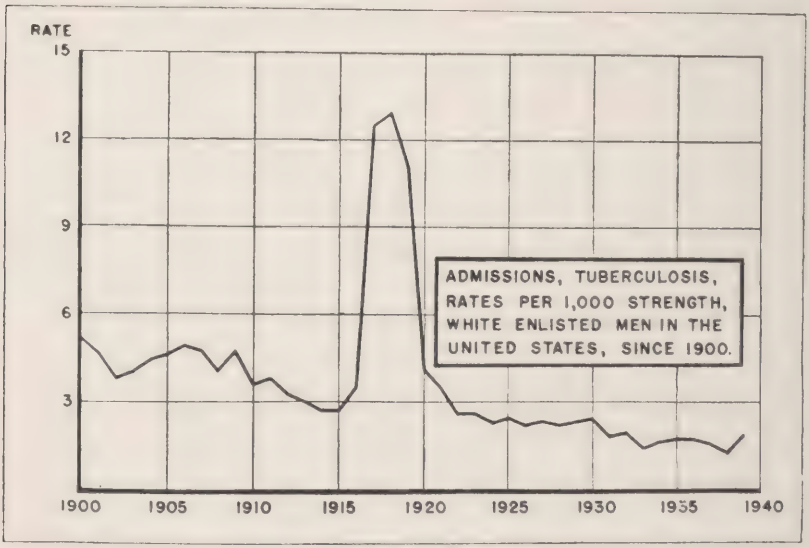


FIGURE 42.

factory for trustworthy interpretation both at the time of the immediate examination and for future reexaminations which might be required 10, 20, or more years thereafter. They must be of a quality which would be satisfactory as legal evidence. In view of the importance of these records, the processing procedure must be such as to insure good keeping qualities of the films. The radiologist must coordinate with the other examiners of the team but the time requirements for proper developing, fixing, and washing must not be sacrificed. In particular, chemicals of the fixing bath must be completely removed, otherwise the films will become stained and brittle and of no value within 3 to 5 years.

42. Methods.—*a.* In some locations, these studies must be accomplished with the use of standard 14- by 17-inch films. When using these films a single exposure will be obtained routinely. Stereoscopic, oblique, and lateral projections may be made on any case which presents suspicious evidence. With consideration as to the large number of individuals to be examined, these dimensions of film studies are not economical, but even more important they are not easily handled for storage or for distributing to examining boards which may be located in any part of the United States. Therefore, wherever the proper equipment is available, these chest studies should be accomplished with the use of smaller film dimensions, as can be obtained with the procedure of photographing the fluoroscopic image (reduction roentgenography, photoroentgenography, photofluorography, etc.). The cost of these small dimension films is so much reduced as compared with the cost of standard films that with the smaller films it is practical to obtain stereoscopic studies routinely.

b. Considering both case finding (diagnostic value) and future reference and trust as far as reviewing boards are concerned, it has been the consensus of Army radiologists that these two methods are the most acceptable for the particular purposes. Fluoroscopy does not provide for the accuracy of study which can be gained by either of these two graphic procedures. Moreover, fluoroscopy does not provide for the maintenance of a graphic record which might be studied by reviewing authorities who are entitled to more than the written report of the first examination. It has been decided that for the miniature film work, the single chest projection should be of approximately 4- by 5-inch dimensions (using a 4- by 10-inch film to obtain a stereoscopic pair).

43. Space requirements.—In most of the examining centers there will be 1 roentgenologist associated with a team of 10 to 15 other examiners. It may be necessary to examine as many as 200 to 400 candidates each day. In order to do this, it is advisable that at least three rooms be alloted for the X-ray service, each being approximately 9 by 12 feet or larger in area, plus the usage of a hallway of no less than 8 feet in width. One of these rooms should be used as an office, one as an exposure room, and the third as a film-processing room. The hallway may be used to accommodate a line of waiting candidates while obtaining from them the necessary information for developing the individual captions (see par. 50). Figure 43 is a "type" plan and lay-out.

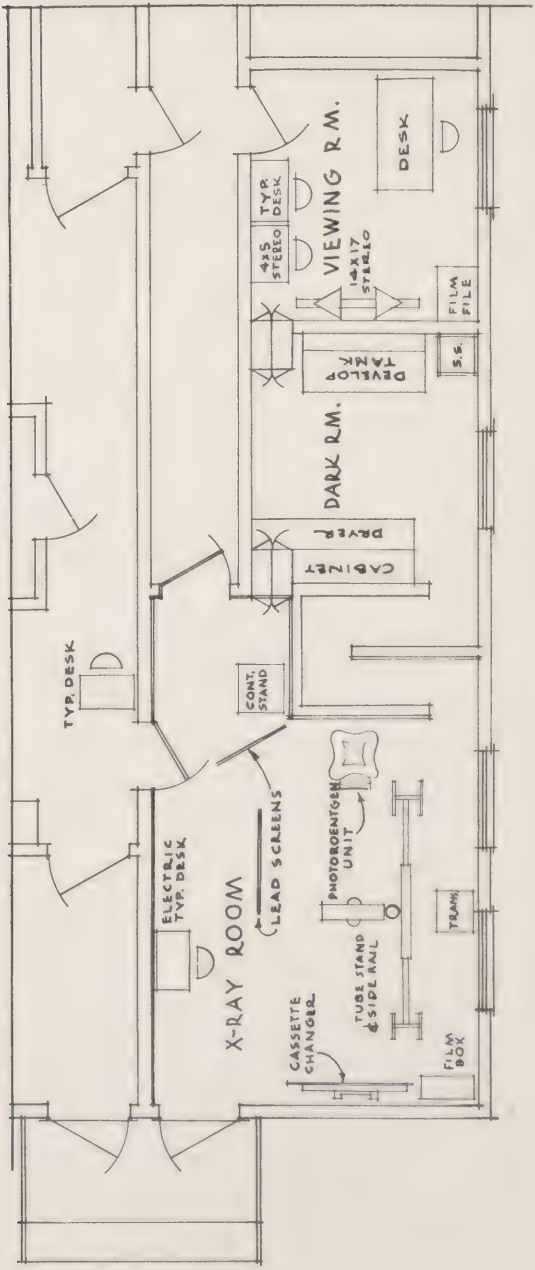


FIGURE 43.—Type lay-out of X-ray equipment for induction center.

44. Equipment requirements.—The equipment should include the following items:

a. Office.

1 stereoscope complete, item No. 61360, to accommodate 14- by 17-inch films.
1 stereoscope to accommodate 4- by 5-inch (or 4- by 10-inch) films.
1 standard typewriter, 11-inch, item No. 76680.
1 office desk.
2 typewriter desks.
3 chairs.
1 filing cabinet.

b. Hallway.

1 typewriter desk.
1 special typewriter (bulletin type characters).

c. Exposure room.

1 item No. 60890, machine, radiographic and fluoroscopic, stationary, complete, 200 Ma.
1 item No. 61692, tube column unit, rail-mounted, heavy duty.
1 item No. 60117, cassette changer, stereoscopic, upright, magnetically controlled to accommodate two 14- by 17-inch films.
1 photoroentgenographic camera unit, complete with stereoscopic shifter and remote control device for making two 4- by 5-inch films of chest on one 4- by 10-inch film.
2 item No. 61310, screen, lead protective.
1 bin, film, portable, lead-lined, two-compartment.
1 adjustable wafer grid.
1 caliper, rule type.
1 machine, electric, for perforating lead strips.

d. Film processing room.

1 item No. 96055, loading bin, dryer, and loading bench combination.
1 item No. 96115, film-processing unit.
Lightproofing provisions: if necessary, darkroom tent (item No. 96175).
8 packages item No. 13800, powder, fixing, photographic.
4 cans item No. NS 1, developer, Kodalk, q. s. 10 gallons.
2 spools, item No. 20340, plaster, adhesive, 1-inch.
4 item No. 60110, 14-inch cassettes.
10 dozen item No. 60190, X-ray films, 14- by 17-inch.
6 packages item No. 61240, preserver, negative, 14-inch.
100 dozen, films, X-ray, single emulsion, 4- by 10-inch.

36 hangers, film, holding 3 each 4- by 10-inch films.
100 dozen, preserver, negative, for 4- by 10-inch films.
24 item No. 60390, holder, film development, 14-inch.
6 rolls, paper, bond, 3¼ inches wide, perforated every 2¼ inches, length 250 feet.
900 item No. 75415, envelopes, white.
2 packages lead foil strips (100).

45. Camera unit.—*a.* The camera unit as used for photographing the fluoroscopic image consists of a lens, a film holder, a lightproof compartment inclosing these, and a supporting column (see fig. 44).

b. There is no unanimity of opinion as to the best type of fluorescent screen. Some of the screens in use today fluoresce wave lengths of the

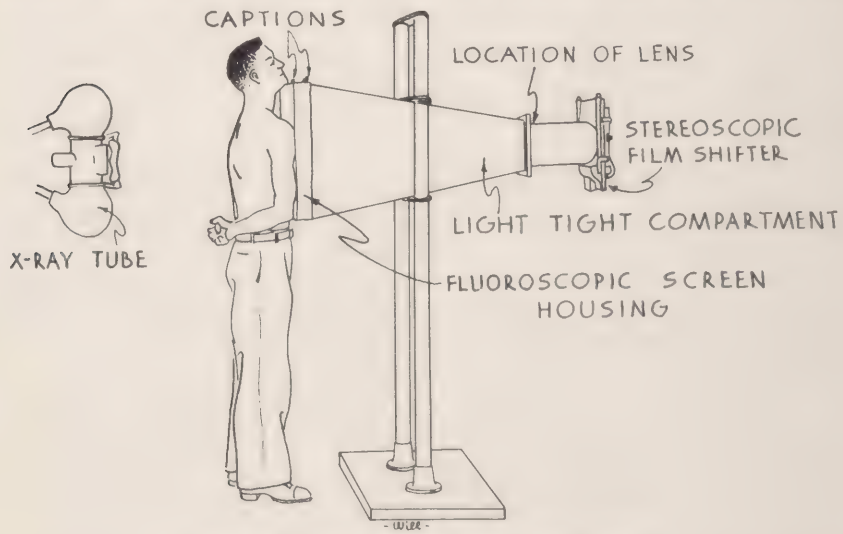


FIGURE 44.—Photography of fluoroscopic image.

blue-violet range while others fluoresce wave lengths of the yellow-green range. The wave lengths of the fluorescent rays determine the type of film which should be used and vice versa. Some concern has been mentioned relative to the size of crystals contained in the fluorescent screen. In the case of certain screens, it is true that the greater the intensity of fluorescence, the larger is the dimension of the crystals. Because of the factor of reduction, as utilized in this type of work, the size of the crystals of the fluorescent screen is unimportant, provided the films are viewed in relatively small dimensions—dimensions considerably less than those of the fluoroscopic screen image.

c. It is desirable that the lens of this unit have a uniform refractory power which is equivalent to that of F 1.5. With such a lens, when using a focal-fluoroscopic screen distance of 40 inches, the exposure technique required for these chest studies is little more than that required for standard 6-foot chest studies (provided a suitable fluorescent screen and film are used). With the use of lenses of slower refractory powers, as for instance a lens of F 2.0 or slower speed, the exposure requirements are more than doubled, thereby requiring considerably greater punishment upon the X-ray tube with resulting shorter tube life.

d. The film should have the smallest grain size possible, otherwise unsharpness of detail will result. The reduction factor does not offset the adversities concerned with grain size of the film emulsion as it does with grain size of the fluorescent screen emulsion. It is advisable that the film have a single coating of emulsion with a nonhalation backing, rather than that it be a duplitized film as conventionally used in X-ray work. Light rays are readily reflected and diffracted. Since fluorescent rays are light rays, they are subjected to deviations in direction when passing through a front layer of film emulsion and through the film base, finally to become effective upon a second layer of emulsion. This accounts for considerable unsharpness of detail when photographing the fluoroscopic image with the use of duplitized films. To some extent, this effect is found with the use of conventional intensifying screens in ordinary roentgenography, but when applied to photoroentgenography, because of the miniature dimensions of the total image, the relative degree of unsharpness is of greater importance.

e. To meet the requirements of almost automatic coordination with the other examiners of the team, it is advisable that the two projections concerned with each candidate be included on one film. Particularly with smaller miniatures, this may be accomplished with the use of a roll type of film. These provisions lessen confusion in the darkroom and alleviate a "bottleneck" which may otherwise occur because of having to match the two-exposure studies concerned with each individual. The services of one technician are practically eliminated thereby.

f. In order to provide for true stereoscopic projections, it is important that provision be made for automatic shifting of the film. The direction of this shifting must be coordinated with respect to the direction of the movement of the X-ray tube and the design of the stereoscopic viewing apparatus. These interrelationships must be checked by preliminary exposures. With stereoscopic viewing, these

films should project the image in the very same relationship to the viewing eyes as the part bears a relationship to the X-ray tube. Otherwise, only pseudostereoscopic studies will be obtainable. Hence it is important that the design of the film holder be such as to provide for movement of the film, either upward or downward, and that it be adapted to the particular design of X-ray tube column and stereoscopic viewing unit in use. Electromagnetic or remote control of the film shifting should be coordinated with the remote control of the X-ray tube shift in order to accomplish satisfactory results, obtaining two exposures within the time limits during which the average individual is able to withhold breathing.

46. X-ray machine unit.—It is preferable that a high milliamperage capacity unit be used. If the exposures are made at milliamperages of 400 or 500, the exposure time can be reduced to values whereby voluntary movements and movements of the vessels might not be troublesome. Lower milliamperage values may be used: in fact, milliamperages as low as 30 have been used (with the focal-fluoroscopic screen distance reduced to 30 inches), though in such cases the exposure time must necessarily be increased, with the attendant adversities. For most of the installations it has been found practical to use 200-milliampere full-wave (rectified) equipment. Particularly when utilizing an X-ray machine unit at its rated capacity load, it is important that the regulation of the transformer be such that its wave form is not distorted at the high milliamperage settings, so that the radiation performance will be truly consistent with the milliamperage.

47. X-ray tube.—Because of the reduction factor, the dimensions of the effective focal spot of the X-ray tube are not important. The detail obtainable when using a small focal spot such as that of a rotating anode tube is not discernibly different from that obtainable when using a tube with a large focal spot. Therefore, it has been considered practical to use a stationary anode tube. To accommodate repeatedly a milliamperage load of 200, it has been considered practical to use an effective focal spot dimension of 5 millimeters square (plus or minus 2 millimeters). Since this work requires exposures of high capacity values, and since these exposures must be made in rapid succession, it is important that, in addition to milliamperage tolerances, both heat storage capacity and heat dissipation characteristics of the X-ray tube are respected. With consideration of 30 centimeter chests and the handling of one such per minute, the requirements would approximate 860,000 heat units (Kvp × Ma × time and seconds) per hour.

48. Film processing equipment. *a.* Because of having to utilize large film roentgenograms for some cases, film processing equipment should be of design adequate to accommodate standard 14- by 17-inch films.

b. The equipment should provide for controlling the temperature of the chemicals (the developer and the fixing bath) to within a range of between 60° and 70° F. This is best accomplished with the use of a thermostatic regulator. The time-temperature method of processing should be practiced. The temperature of the final wash water may be as low as 50° F. or as high as 80° F. For adequacy of washing, the most important factor is circulation of the water and supply of fresh water. If a cascade design of wash compartment is provided, the movement of the water is more effective than in the case of a large, open tank and therefore exchange of water may be less. In order to accomplish satisfactory washing within 10 to 15 minutes with an open tank, it has been estimated that a fresh water supply of eight times the volume of the tank per hour is required, whereas with a cascade arrangement only four times the volume is needed. In the case of the United States Army processing unit (par. 24), when the auxiliary wash section is used this comparison would mean 60 gallons per hour (4 times the volume of the final wash compartment) versus approximately 360 gallons per hour (8 times the volume of the circulating water) when the master chemical section alone is used.

c. Since film life is so important where the film studies are to serve as legal records, as in the induction board activities, it is very essential that adequate washings are accomplished. Otherwise residual sulfur on the film emulsion will produce a staining of the film within a period of a few years and the film will become brittle and fragment within 4 or 5 years. Periodic testings should therefore be accomplished to ascertain the adequacy of the washing. A simple yet accurate qualitative test for residual hypo may be performed with the use of a very dilute solution of potassium permanganate ($KMnO_4$) as an indicator. This may be made up from a stock solution such as the following:[1]

	Metric	*Avoirdupois*
Potassium permanganate	0.5 gram	7.5 grains.
Sodium hydroxide (caustic soda)	1.0 gram	15.0 grains.
Water (distilled) to make	1.0 liter	32.0 ounces.

Use 1 part of stock solution to 20 parts of water. In lieu of these detailed preparations, it is practical merely to add a small

[1] Courtesy Mr. F. C. Martin, Eastman Kodak Company, Rochester, N. Y.

crystal of the potassium permanganate to approximately 500 cubic centimeters of distilled or ordinary tap water. In case tap water is used, the resulting solution should be allowed to stand for 10 or 15 minutes in order to make certain that the organic content is not sufficient to reduce the manganese ions. The solution thus made should be pinkish violet in color and should remain so regardless of standing for 10 or 15 minutes. Twenty to 40 cubic centimeters of the very dilute indicator, prepared by either method described above, should be poured into each of two test tubes or beakers (one aliquot for the testing, the other for a control). A film should be removed from the wash section and allowed to drip into one of these two testing containers; 15 to 20 drops should suffice. If within a period of 5 minutes there results a change in the color of the indicator from a pinkish purple to orange, yellow, or a colorless solution, the washing of the film has been inadequate. Such testings should be accomplished periodically after allowing the routine periods and conditions of washing the films.

49. Time requirements.—With improvements of chemicals, the time required for developing may be reduced to $3\frac{1}{2}$ minutes (though 6 minutes may be given, with reduction of 3 to 6 kilovolts in the exposures as compared with regular techniques); the intermediary wash should not require more than a few seconds; 10 minutes should be allowed for adequate clearing in the hypo bath, and the films should be washed for 10 to 15 minutes (provided cascade type of washing is used). The time required for drying will depend to some extent upon the design of the film hangers. When stereoscopic viewing is to be accomplished, the films should be dried thoroughly. However, for direct viewing, the wet films can easily be handled and it is not impractical nor annoying to study them in that condition. Thereby, reporting of the films can be accomplished within one-half to three-quarters of an hour following the time of making the exposures. Thus the roentgenological team can coordinate very closely with the activities of the other examiners.

50. Film captions.—*a.* To provide for adequate identification of the films, two captions should be used. The characters of these captions should be of a vertical dimension of no less than one-quarter inch. Their style should be of plain block bold-face capital letters such as those of "bulletin type." Otherwise, reading them may be difficult after reduction to the dimensions of the miniature films. Detailed information should be recorded. This may be accomplished with the use of two small captions, utilizing the spaces of the screen and film, above the shoulders. One of these captions should

include the following information: location of the examination; examining board number; date; and orientation as to the side of the body. This caption may serve for all the examinations conducted during any 1 day. It may be left in place, either in the upper right or left corner, depending upon the arrangement of the room and ease of handling the other caption. The other caption should include name of the candidate (last name, first name, and middle initial); street address and locality of residence; local board number; color, age, height, and weight. The following are sample captions:

Caption 1	*Caption 2*
STATION HOSPITAL	VAN BLARICON, HAROLD R.
FT. SAM HOUSTON, TEX.	1543 HANOVER ST.
ARMY EX. BD. NO. 54	DALLAS, TEX.
DEC. 12, 1941	LOC. BD. NO. 169
LEFT	W, 32, 68, 154

b. After making the exposures on each candidate, caption 2, as shown above, should be removed and placed in a basket and later fixed to a filing envelope. The film itself should be kept in this envelope. This arrangement provides for a most trustworthy identification of those films on which the projected captions are only moderately legible. In addition, this plan is time saving as compared with writing the identifications on the outside of each envelope.

51. Technical assistance.—*a.* When close coordination with other members of an examining team is required and when several hundred individuals are to be examined in a day, it is recommended that the X-ray team consist of at least six assistants, in addition to the roentgenologist. The activities of these assistants might be as follows:

(1) *Secretary and filing clerk (No. 1).*—The duties of this assistant would include general secretarial work such as recording interpretations, filing records, and handling correspondence.

(2) *Captioning stenographer (No. 2).*—The duties of this assistant would be similar to those of assistant No. 1. In particular though, he would record the data as reported by each individual, developing thereby the identifying captions. It is estimated that the roentgenography of 200 individuals (400 exposures) can be accomplished within a period of 4 hours. If this number were admitted in a steady line, this assistant might be borrowed from other activities of the examination center for such a period of time.

(3) *X-ray machine operator (No. 3).*—This assistant must be a well-qualified X-ray technician. His duties should include not only

the handling of the controls of the machine but he must bear responsibilities for proper maintenance of the equipment and for obtaining satisfactory roentgenographic densities. He should be familiar with a kilovoltage penetration technique and vary the settings of the autotransformer according to the measurements of the chest, as reported to him by No. 4 assistant.

(4) *Positioning assistant (No. 4).*—This man should likewise be a well-qualified X-ray technician. He should be a "pinch hitter" in case of disability of No. 3 assistant. When coordinating with the entire team, his duties should consist of properly positioning the individual and the X-ray tube. As the individual advances toward the fluoroscopic screen, he should measure the diameter of his chest (at the nipple level) and announce this measurement to the X-ray machine operator. He should then carefully position the individual in front of the plane of the screen or cassette panel, with his chest leaning forward (so as to expose the apices). He must insure symmetrical approximation of the chest and rotate the upper extremities so as to clear the scapulae as much as possible. The cassette or screen should be raised high, extending the chin of the candidate, and then the focal spot of the X-ray tube should be alined to the center of the field, shifting either way from the center for stereoscopy. Routinely, the long axis of the X-ray tube should be perpendicular to the floor, with the cathode end up, so as to provide for the greatest radiographic intensity through the apices and through the captions. Before the exposures are made, No. 4 assistant should step away from the tube and behind a lead screen so as to avoid unnecessary X-radiation exposure (the accumulation of minimal leakages which are to be expected even through modern ray-proof housings).

(5) *Film handler (No. 5).*—This assistant should obtain the caption of each candidate as he advances toward the radiographic unit. He should remove any caption already present (as described in par. 50*b*) and replace it with the one pertaining to the individual. While the candidate is being positioned by assistant No. 4, he should prepare the film for the first exposure. If automatic shifting is not provided, it will be necessary manually to change the film between the two exposures. A lead screen should be provided and located adjacent to the film holder so as to protect this assistant against unnecessary X-radiation and yet permit him to be sufficiently close to the film holder so as to arrange for changing of the film (within reasonable time limits of holding one's breath). This assistant should also accomplish a liaison between the exposure room and the processing room

and between the processing room and viewing room or office. With the roll type of film many of these services become unnecessary.

(6) *Film processor (No. 6).*—This assistant will be responsible for loading and unloading all films as well as processing them. He must expedite all phases of the processing, avoiding unnecessary delay particularly during fixation and washing, so that films can reach the roentgenologist within one-half to three-quarters of an hour following the actual exposure.

b. It is apparent that with considerable rush of activities the services of an additional assistant may be necessary, particularly for coordination between the processing room and the exposure room or the office. With lesser activity the number described above may be superfluous. The duties of assistants Nos. 1 and 2 may be consolidated as well as those of Nos. 3, 4, and 5, whereby a team of three assistants plus the roentgenologist may function without difficulty.

52. Technical factors.—*a.* It is not possible to present definite factors which may be trusted for use with any and all X-ray machines. The following outline is therefore presented merely as a guide. These factors have been found suitable when the wave form of the high-tension circuit is of average quality. It must be realized that where distortion of wave form is encountered, somewhat greater exposures will be required. When the wave form is of the highest quality, exposures as great as those listed will not be necessary. Factors other than wave form may also be involved, for example, variations in milliammeter recordings, variations in X-ray tube performances, etc.

b. It will be noted that relatively high kilovoltage values are suggested. There are several reasons for this policy:

(1) It serves to counteract an otherwise excessive contrast; by doing this, it provides for visualizing the peripheries of the lungs in the regions of the rib cross-overs without overexposing the hilar thirds.

(2) It provides for reduction of exposure time, thereby minimizing the adverse effects of motion.

(3) It provides for exposures with radiographic density which require considerably less heat units than those which would be required if lower kilovoltages and higher milliampere-second factors were used, thus actually reducing, relatively, the punishment upon the X-ray tube. However, in addition to considering heat unit requirements, insulation tolerances of the shockproof cables, the X-ray tube envelope, its terminals, and those of the high-tension transformer must be respected. At the present time, a kilovoltage of 90 should not be exceeded.

c. In order to provide for sufficient contrast where secondary fog would otherwise obscure the detail, it is advisable for chests having a measurement of 25 centimeters or more to place a wafer grid in front of the fluoroscopic screen. The standard portable grid (item No. 96070) serves well for this purpose. With this grid, it is merely necessary to increase the milliampere-second value to twice that which would be used without it. This compensatory increase is considerably less than that which would be required for a moving grid having the same ratio (5 to 1) or for grids in which the lead strips are thicker than those of the Army wafer grid. However, even the double milliampere-second value means considerable increase in X-ray tube punishment. Special consideration of tube capacity must be given. After accomplishing the exposures on a large-chested individual, it is advisable to allow 1 or 2 minutes before proceeding with further exposures. It must be emphasized that the Army wafer grid has been constructed to a definite radius, 36 inches (though it is usable with distances as great as 48 inches), and for this reason it is important to place the top side of the grid toward the patient while the film side of the grid is toward the fluoroscopic screen.

TABLE I.—*Photoroentgen technique*

Thickness (cm)	Kvp	With grid		Without grid	
		Ma.	Time	Ma.	Time
16	72	200	1/5	200	1/10
17	74	200	1/5	200	1/10
18	76	200	1/5	200	1/10
19	78	200	1/5	200	1/10
20	80	200	1/5	200	1/10
21	82	200	1/5	200	1/10
22	84	200	1/5	200	1/10
23	86	200	1/5	200	1/10
24	88	200	1/5	200	1/10
25	90	200	1/5	200	1/10
26	90	200	1/5	200	1/10
27	90	200	3/10	200	3/20
28	90	200	3/10	200	3/20
29	90	200	2/5	200	1/5
30	90	200	2/5	200	1/5

Section VII

DIAGNOSTIC ASPECTS [1]

53. General.—*a.* There must be a scientific evaluation of roentgen findings. Mere search for typical pictures of pathology will lead to too many mistakes—failure to recognize important lesions; errors due to exaggeration of the unimportant. Very conspicuous lesions may be unimportant whereas relatively inconspicuous changes may be cause for rejection or for treatment. Interpretations must depend upon an orderly sequence of analyses: consideration of the soft tissues, the bony thorax, the pleurae, the diaphragm, the lung parenchyma, the hilar lymph nodes, the cardiac silhouette, and finally, the trachea and mediastinum. Tangible roentgen criteria significant of changes in any of these must be tabulated, at least mentally, and diagnoses must be based upon deductive reasonings substantiated by factual evidence.

b. The range of diagnostic possibilities is protean. These are well known to qualified roentgenologists. Reference texts should be consulted liberally. Today, roentgenological details are too voluminous to incorporate in any one manual. Since pulmonary tuberculosis is the particular problem with which the Army is concerned during times of mobilization and demobilization, this discussion will be mainly concerned with the criteria of this disease. Reference is directed to the several Army Regulations and circular letters and in particular to MR 1–9, Standards of Physical Examination during Mobilization; AR 40–100, Standards of Miscellaneous Physical Examination: AR 40–105, Standards of Physical Examination for Entrance into the Regular Army, National Guard, and Organized Reserves.

c. The roentgenologist must come to a definite decision relative to the immediate handling of each case. It is realized that follow-up studies are not infrequently indicated for crystallizing opinions as to definite diagnosis. However, candidates for the service cannot be studied as hospital cases. The roentgenologist is simply required to list definite X-ray findings and render an expression as to whether the findings are insufficient to disqualify; whether they should disqualify—indefinitely or "for the present." As a consultant, the roent-

[1] Roentgenological studies of chest as accomplished prior to admission or discharge.

genologist is entitled to know any pertinent details relative to the individual's background such as history of past diseases, his previous occupation, and contacts. He may wish to know of present physical findings and he is entitled to delay the rendering of the report until any such information has been obtained.

d. Though it is not the duty of the roentgenologist actually to classify the individual, the official classification is here listed. Detailed description of the several classes is found in sections XXI, XXII, XXIII, XXIV, and XXV, volume three, Selective Service Regulations.

(1) *Class I.*

Class I–A: Available; fit for general military service.
Class I–B: Available; fit only for limited military service.
Class I–C: Member of land or naval forces of United States.
Class I–D: Student fit for general military service; available not later than July 1, 1941.
Class I–E: Student fit only for limited military service; available not later than July 1, 1941.

(2) *Class II.*

Class II–A: Man necessary in his civilian activity.

(3) *Class III.*

Class III–A: Man with dependents.

(4) *Class IV.*

Class IV–A: Man who has completed service.
Class IV–B: Official deferred by law.
Class IV–C: Nondeclarant alien.
Class IV–D: Minister of religion or divinity student.
Class IV–E: Conscientious objector available only for civilian work of national importance.
Class IV–F: Physically, mentally, or morally unfit.

54. Nontuberculous conditions.—*a.* In general, any condition which may reasonably be expected to inhibit the activities required in military life or serve as an excuse from performing an assignment should be considered basis for disqualification. Moreover, rejection should be recommended where the findings indicate a lesion or condition which may be aggravated by military service or be cited as basis of claim for a pension.

b. As examples of such unacceptable findings the following nontuberculous conditions are cited in regulations:

(1) Tumors of the soft tissues of such size and location as to interfere with the wearing of the uniform or military equipment, or any malignant tumor.

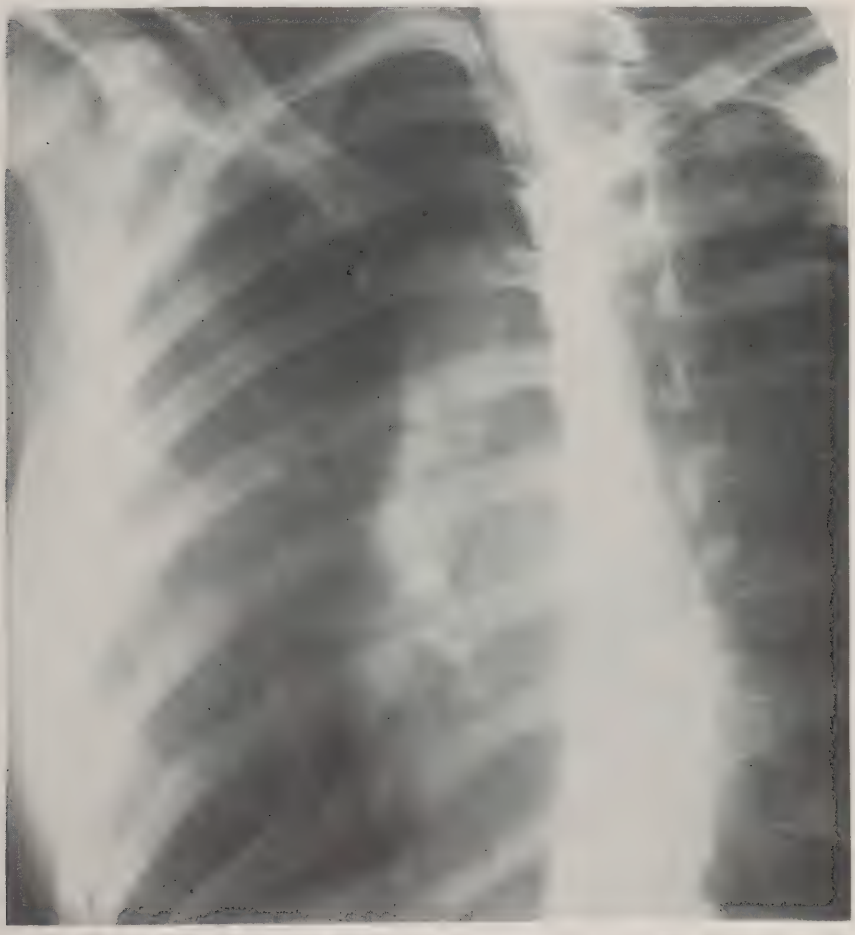


FIGURE 45.—Erosion of sternum by malignant tumor. (Interest was directed to the sternum in this case but routinely the thoracic cage should be studied for invasive or metastatic lesions.)

(2) Anomalies of the thorax such as Sprengel's deformity or dysostosis of the clavicles. Minor degrees of such may be recognized as class I–B provided they do not prevent the registrant from successfully following a useful vocation in civil life.

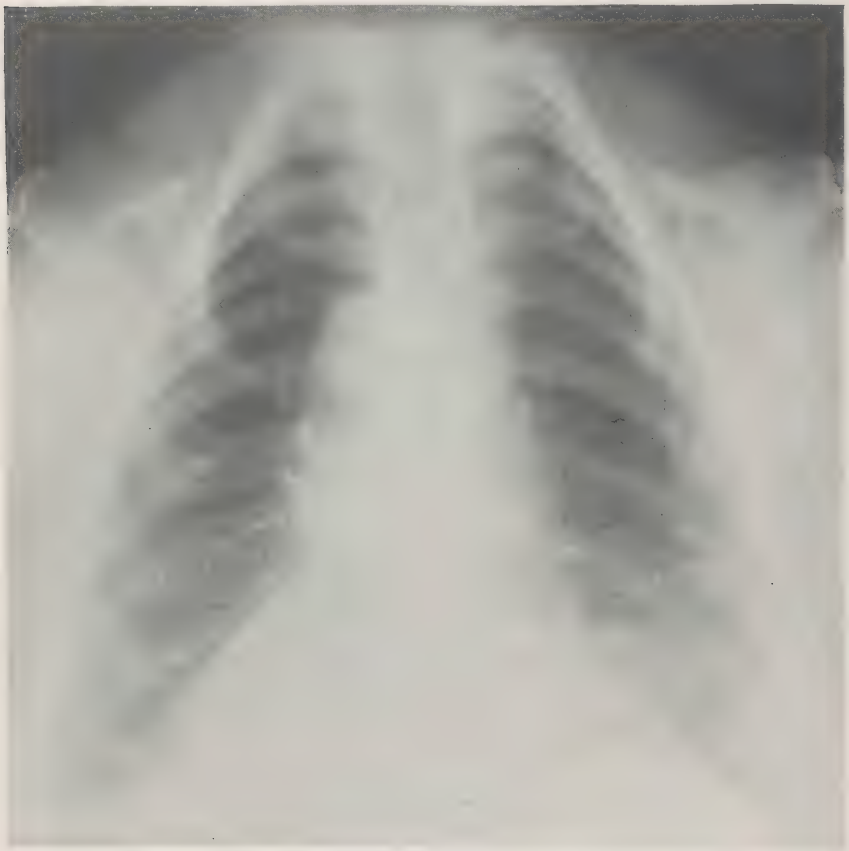


FIGURE 46.—Dysostosis of clavicles. (Note triangular configuration of thorax: absence of clavicles; prominent spines of the scapulae. Some of these individuals can easily handle Army equipment because of compensatory muscular developments.)

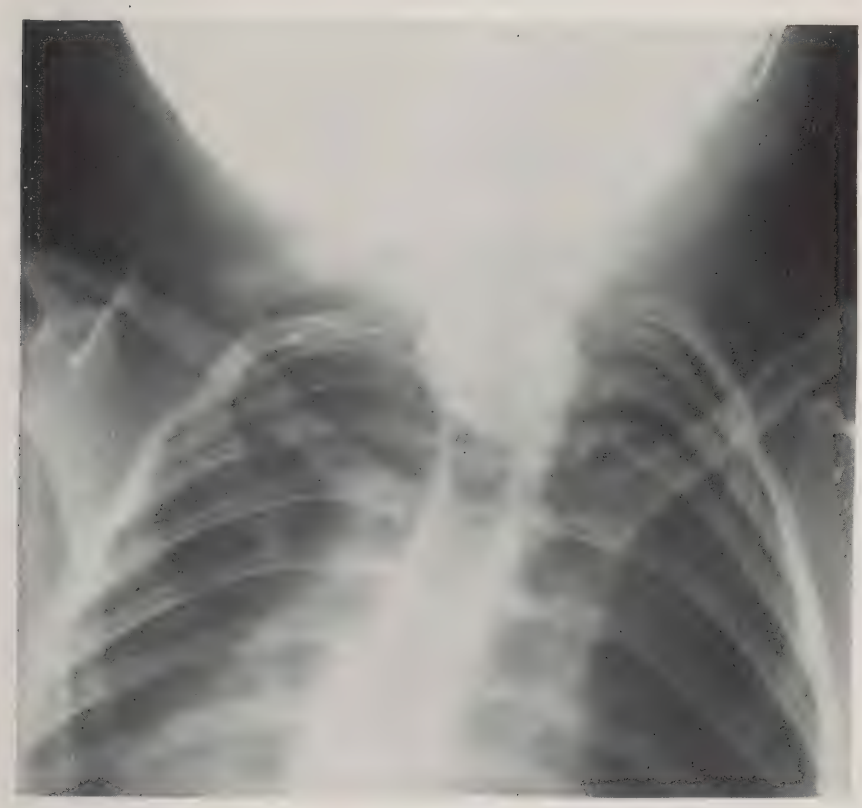


FIGURE 47.—Sprengel's deformity. (Note elevation and rotation of left scapula; fixation to cervical spine (by way of omohyoid process); curvature of spine (compensatory) and other anomalies—in this case, spina bifida involving lower cervical and upper thoracic vertebrae.)

(3) Ununited fractures of the ribs, infections of the ribs (such as actinomycosis), or deformities of such degree as to interfere with physical activities (lesser degrees of such may be classified as I–B).

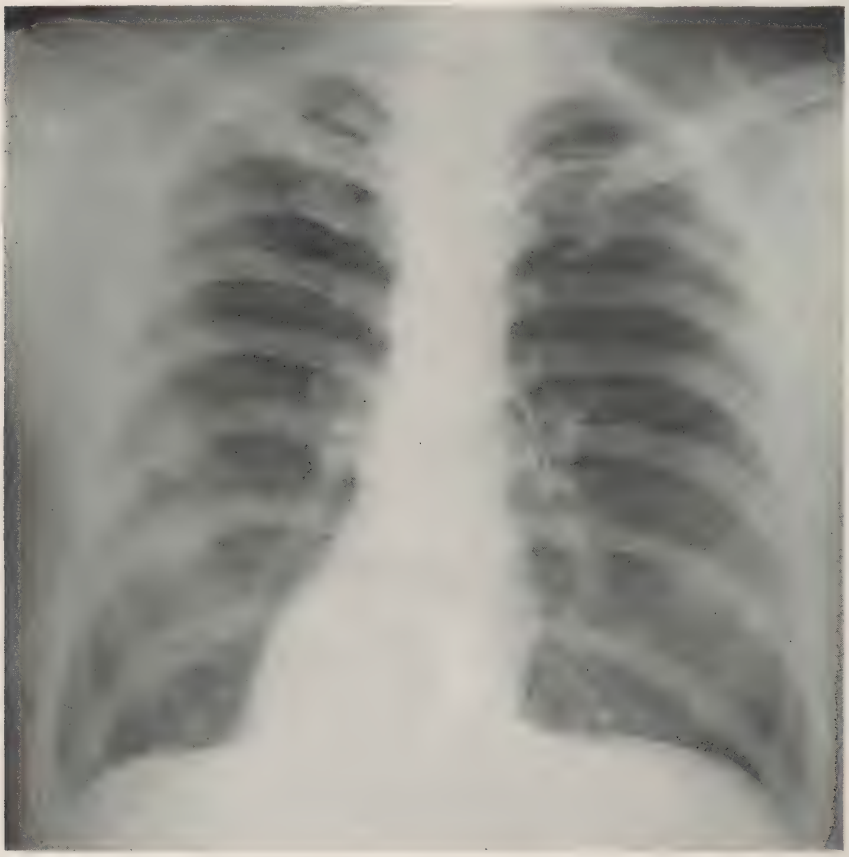


FIGURE 48.—Ununited fractures. (Note residual fracture gaps, eighth, ninth, and tenth ribs, left.)

(4) Herniation or eventration of the diaphragm.

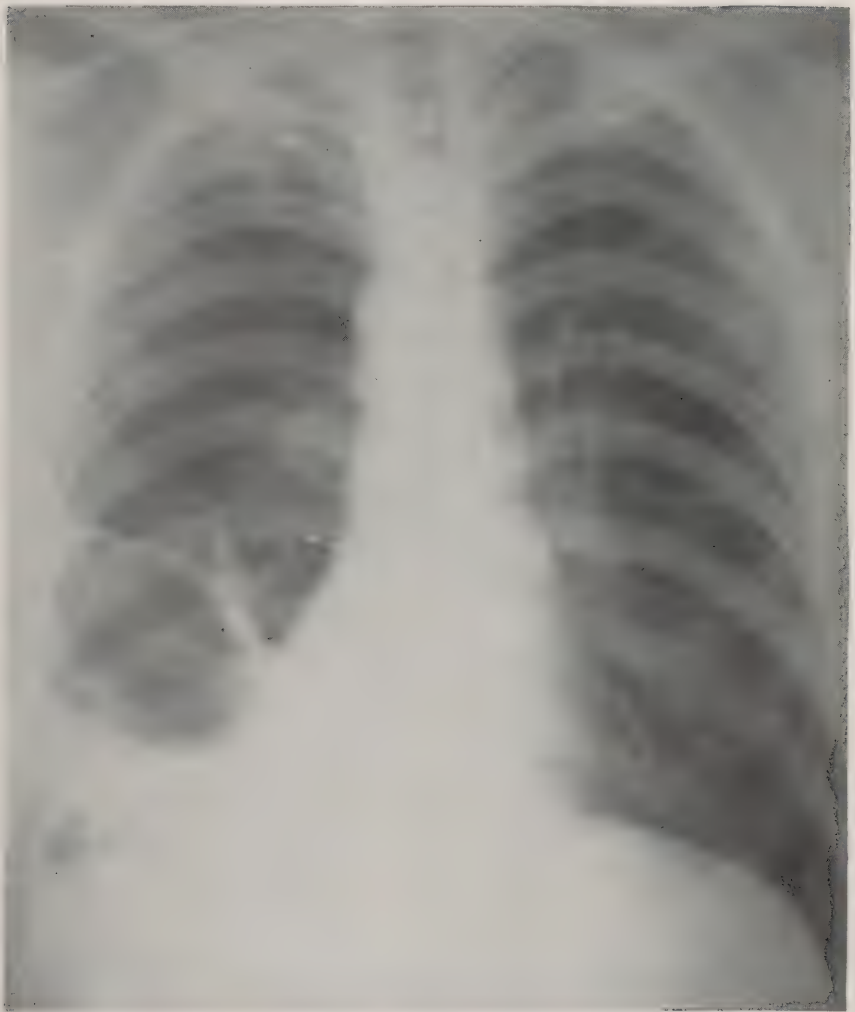


FIGURE 49. Eventration of diaphragm. (Note elevation of entire left dome; air contained in stomach beneath.)

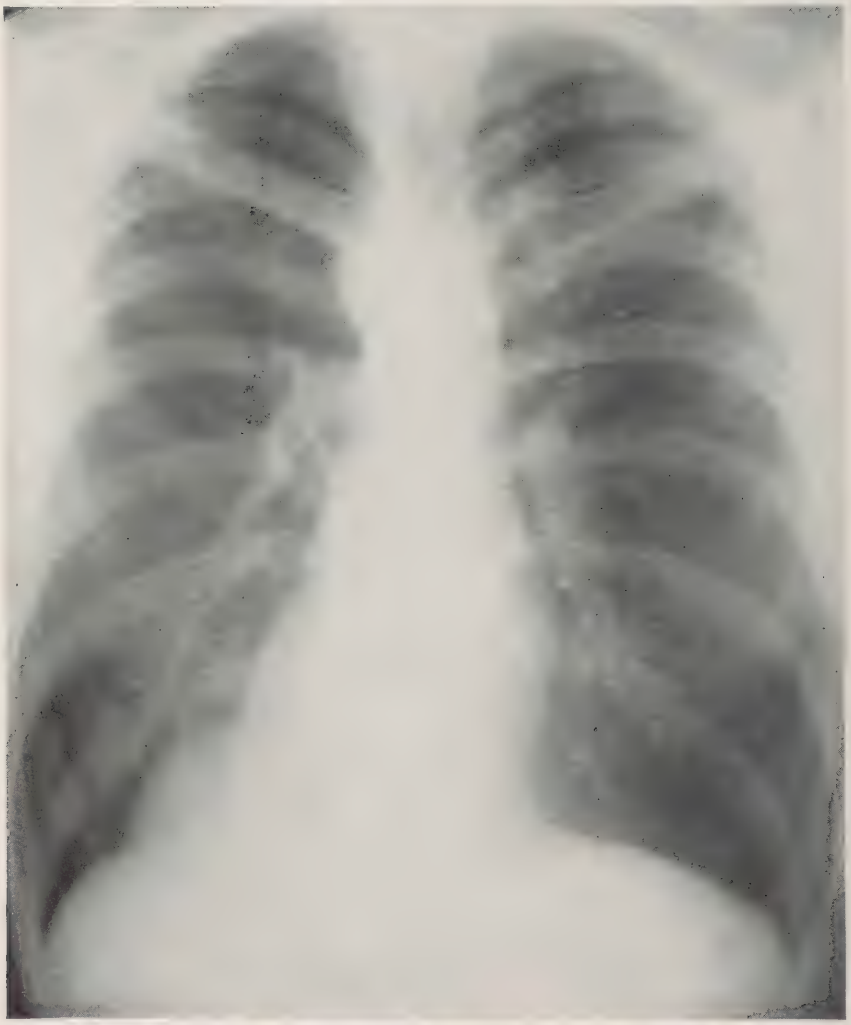


FIGURE 50.—Herniation of diaphragm. (Note relatively normal position of peripheral portions of left dome and sacculation in mesial portion.)

(5) Spontaneous pneumothorax.

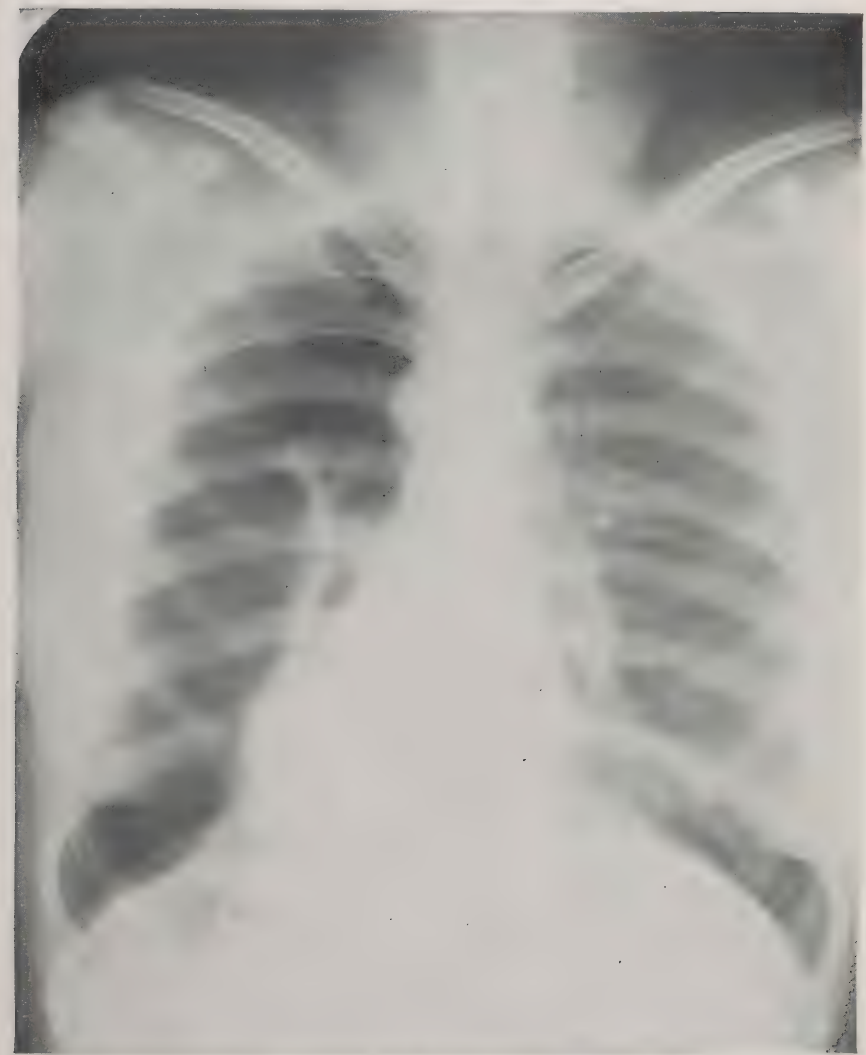


FIGURE 51.—Pneumothorax. (Note absence of pulmonary markings in superior and lateral aspects of left thorax and demarcation of lung boundaries.)

(6) Empyema or unhealed sinuses of the chest.

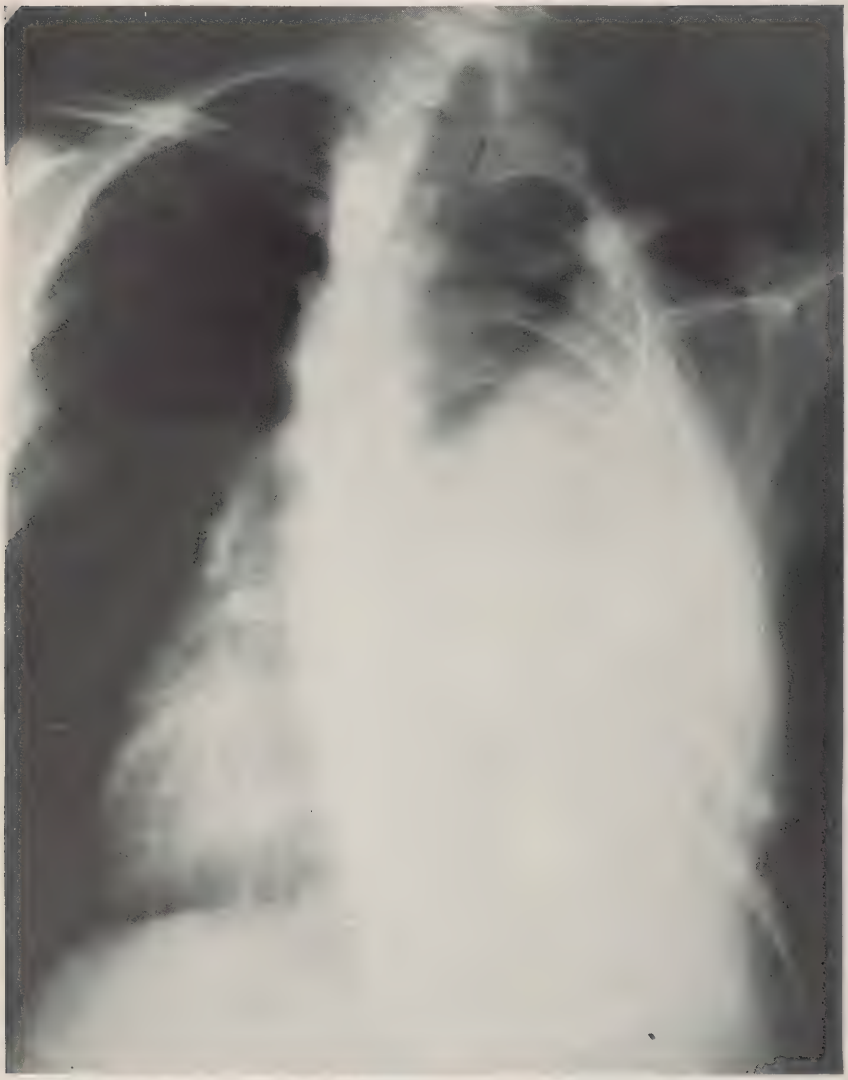


FIGURE 52.—Empyema. (This case is included in order to emphasize the dimensions which may be attained by a walled-off pocket. These may be located in basal, parietal, or interlobar positions. Evidence of free fluid would be disqualifying, though it is less likely that such cases would be physically active.)

(7) Evidence of acute pleural inflammations or chronic pleural thickenings of such degree as to obscure the pulmonary markings over a considerable portion of the lungs such as a volume comparable to the right upper lobe.

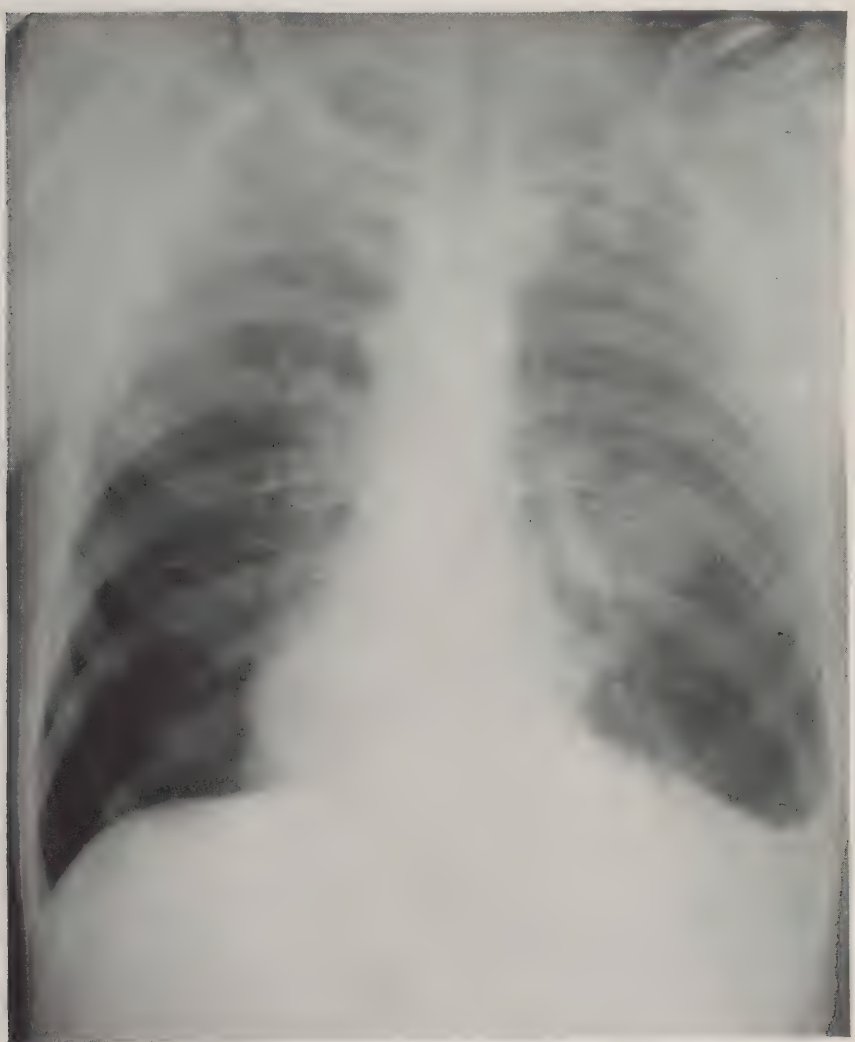


FIGURE 53. Acute pleurisy. (These cases do not always present roentgen evidence. Pertinent criteria may include contraction of ribs; elevation of dome of diaphragm (involved side); localized densities of such degree that pulmonary markings may be discernible through them and possibly evidence of fluid in the diaphragmatic sulcus—all of which criteria can be seen in this case.)

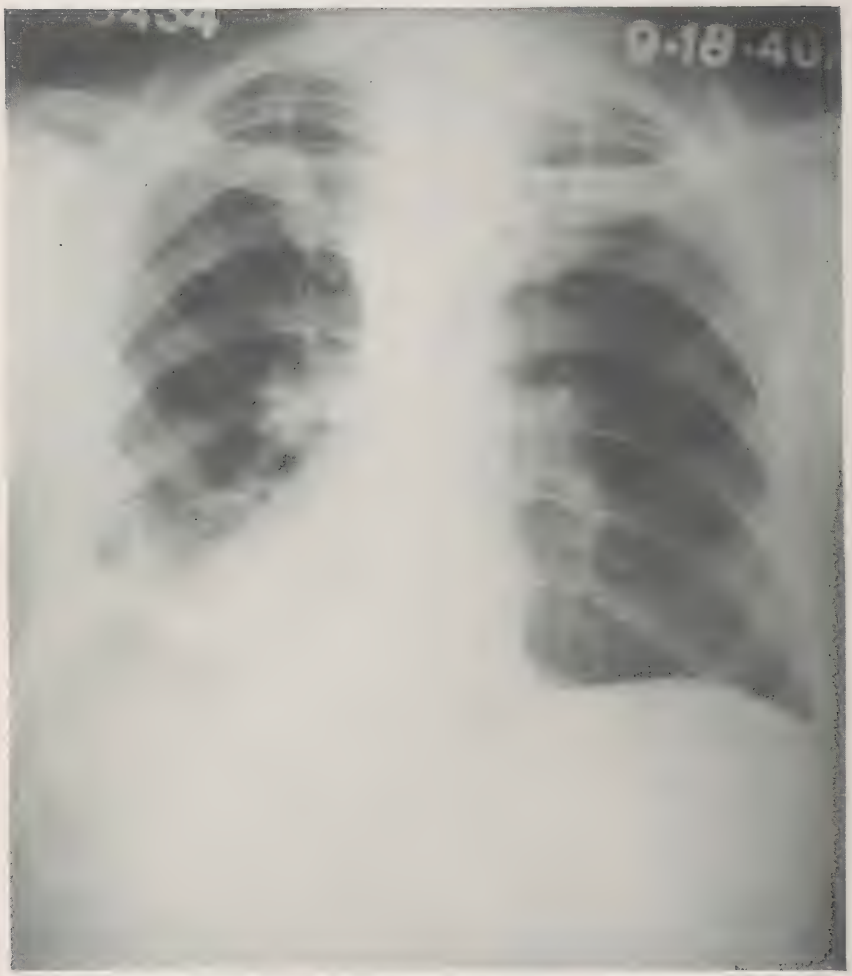


FIGURE 54.—Thickened pleura, residual to chronic process. (The degree of thickening shown in this case is sufficient to disqualify because dormant inflammatory processes may be concealed.)

(8) Tumors of the pleurae.

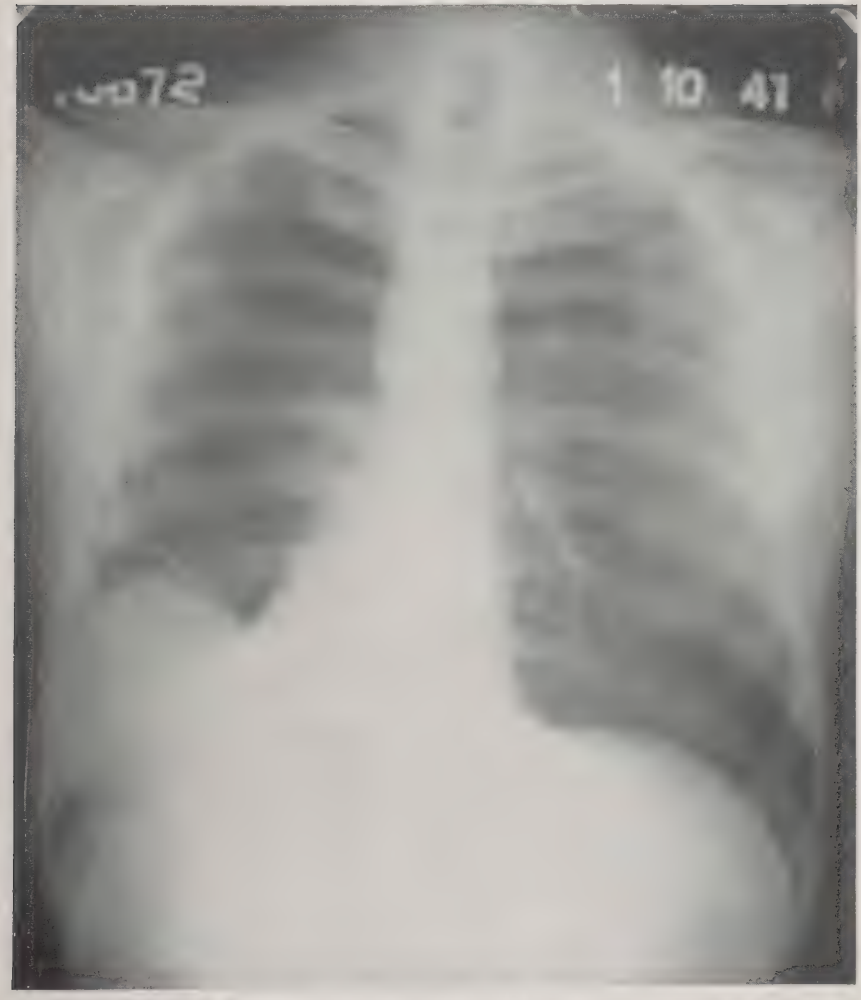


FIGURE 55. Tumor of pleura. (Note multiloculation and complete margination of mass.)

(9) Pulmonary emphysema with impairment of function or definite cystic disease of the lung.

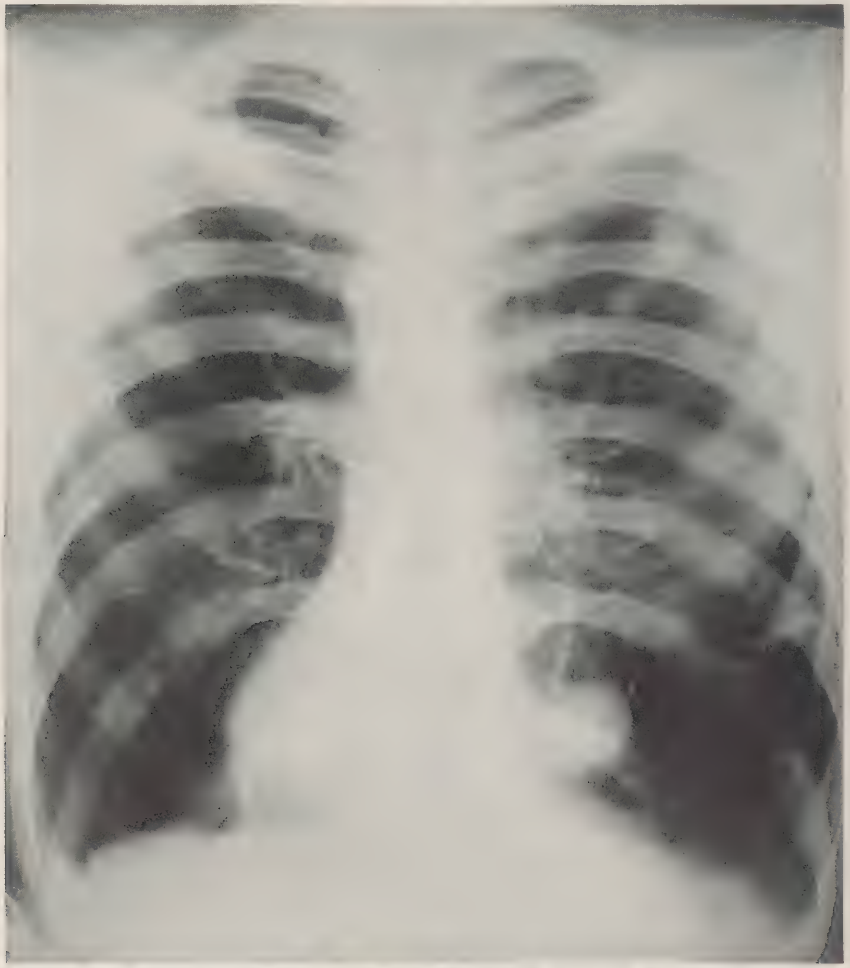


FIGURE 56. Emphysema, both bases. (Note flattening of domes of diaphragm; expansion of intercostal spaces; increased radiographic densities; and honeycomb structure of lung parenchyma. Lateral studies of these cases will oftentimes reveal an increased anterior posterior diameter of the thorax and conspicuous pneumatization anterior to the outline of the heart. This particular case also shows a fibrin ball over the mesial aspect of the right dome.)

(10) Silicosis of so-called second degree or more severe, as manifested roentgenologically by disseminated nodular densities in addition to the strandlike densities and enlarged lymph nodes.

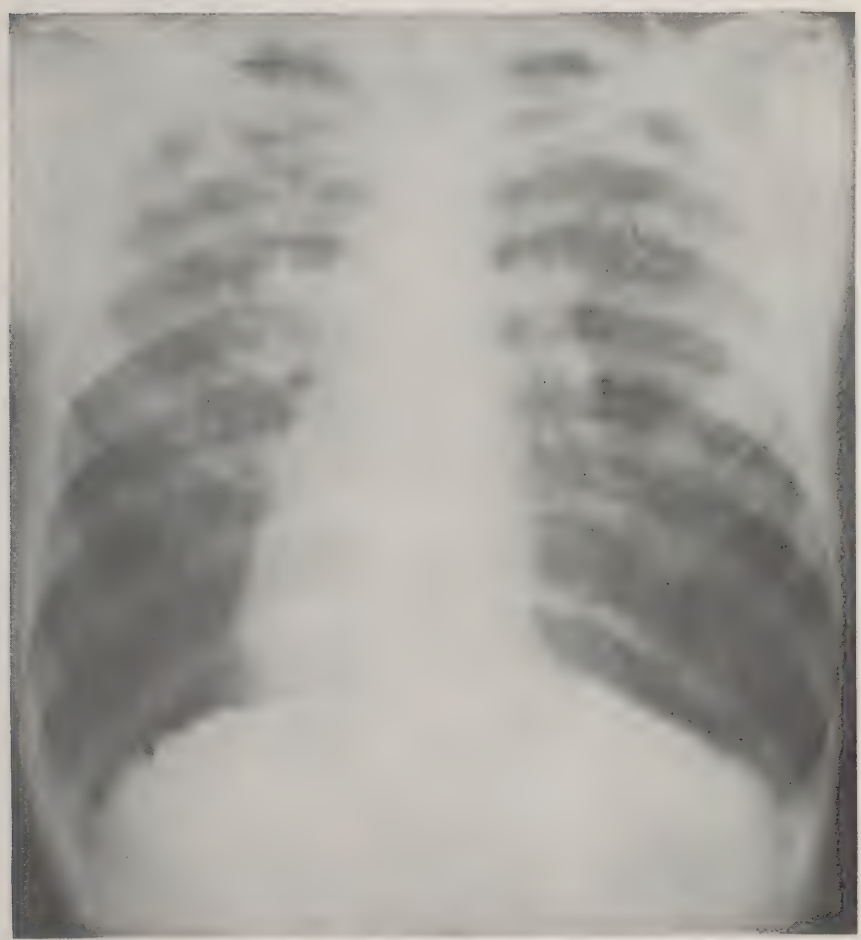


FIGURE 57. Pneumokoniosis, second degree. (Note conspicuous pulmonary markings through all zones of both lungs; disseminated nodular densities in addition to enlarged hilar lymphatics. This particular case shows marked emphysema at the bases.)

(11) Chronic bronchitis with emphysema, bronchiectasis.

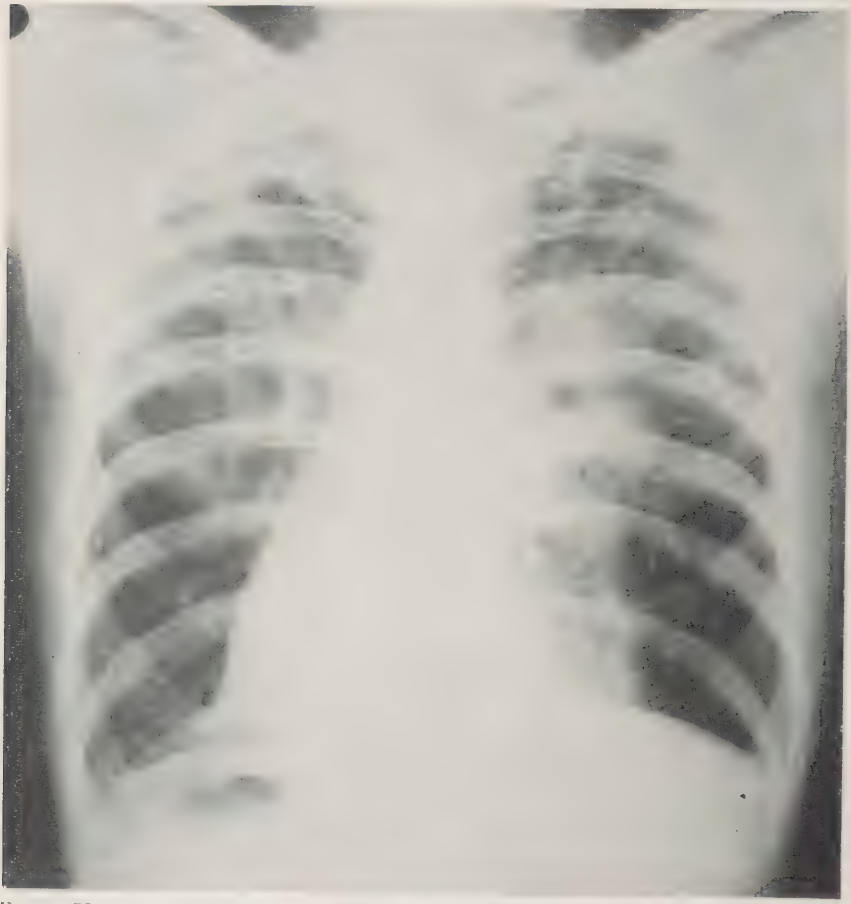


FIGURE 58.—Bronchiectasis and compensatory emphysema. (Note conspicuous pulmonary markings through hilar and midzones of lower lobes—most frequent locations for bronchiectasis: "Swiss cheese" pattern through these areas. The lateral aspect of the right lower lobe shows moderate emphysema. The paranasal sinuses should be studied in cases such as this one, where there is evidence of chronic lower lobe bronchitis.)

(12) Foreign body in the lung.

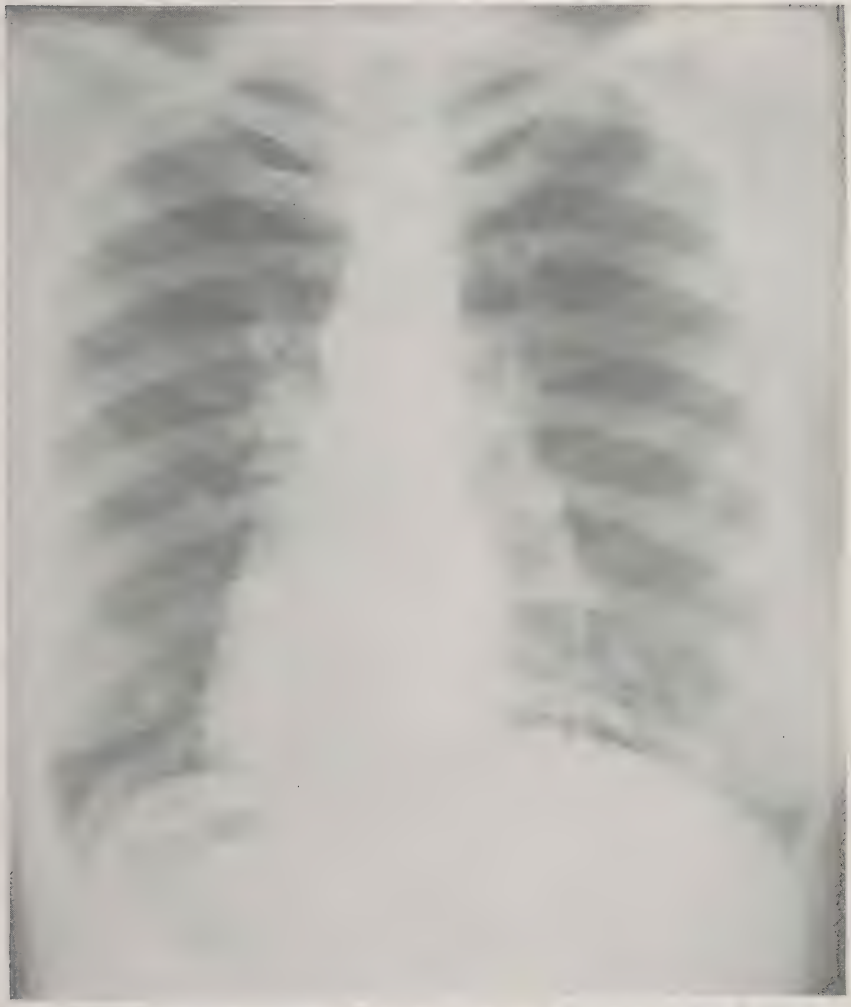


FIGURE 59.—Foreign body in lung. (Note outline of pin in lingular portion of left upper lobe. Metallic foreign bodies may remain for long periods of time without exciting tissue reactions, whereas irritating oils such as contained in peanuts will produce a marked reaction with abscess formation.)

(13) Acute inflammatory lesions of the lung such as bronchitis (may classify as I–B), lobar- or broncho-pneumonia (may classify as I–B), abscess, etc.

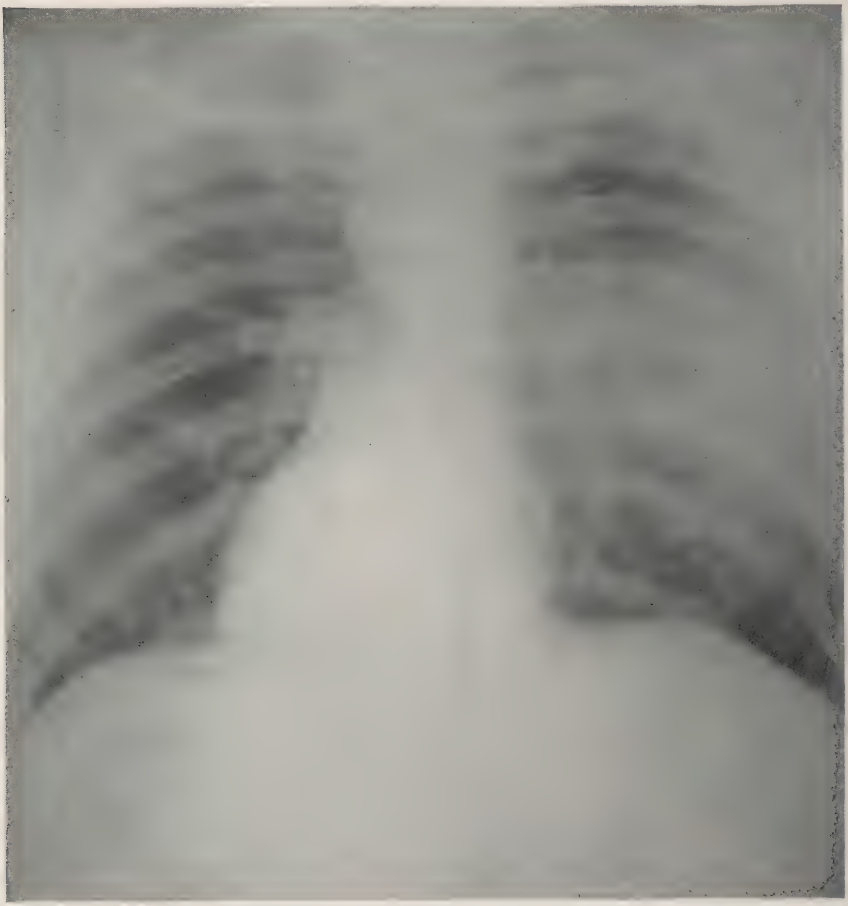


FIGURE 60.—Vincent's pneumonitis. (Marked inflammatory changes such as demonstrated in this case may occur in mycotic infections or in infections by Vincent's organisms without there being extreme physical depletion.)

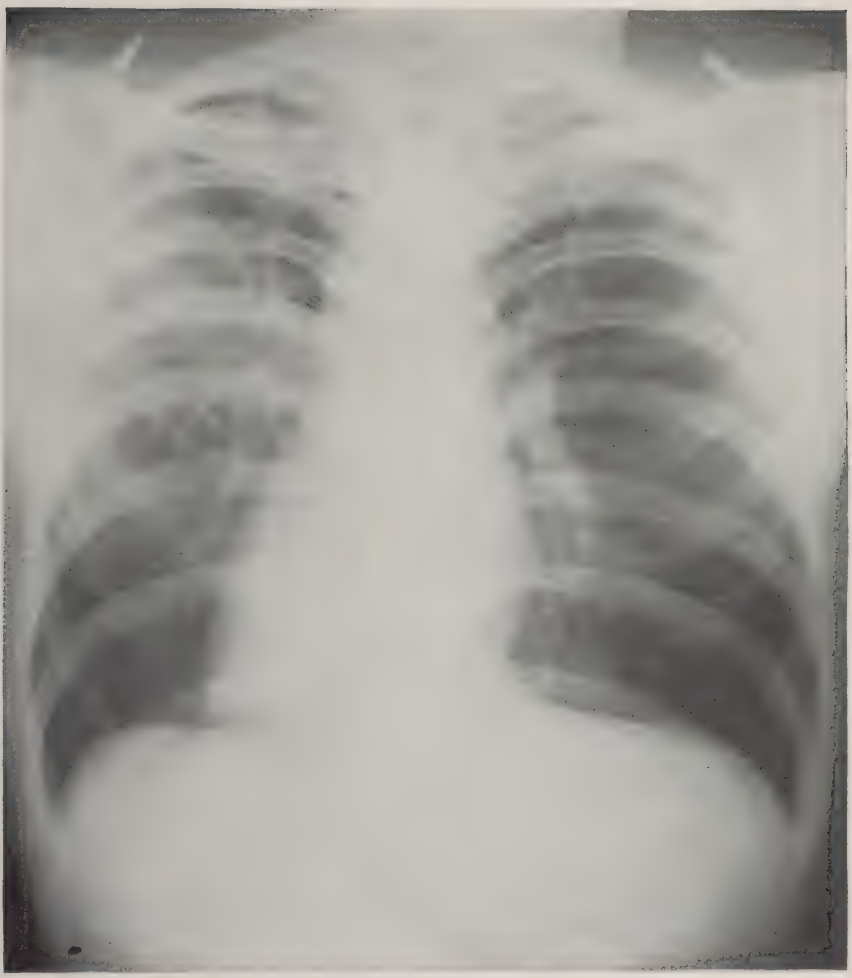


FIGURE 61.—Mycosis of lung. (The roentgen criteria may very closely simulate those concerned with reinfection tuberculosis but considering the degree of involvement, the patient is likely to be in better physical condition if the lesions are due to fungus. Moreover, except in the case of the ray fungus (actinomycosis), fungus lesions may become moderately advanced without there being any conspicuous nodular lesions.)

(14) Tumors of the lung or mediastinum.

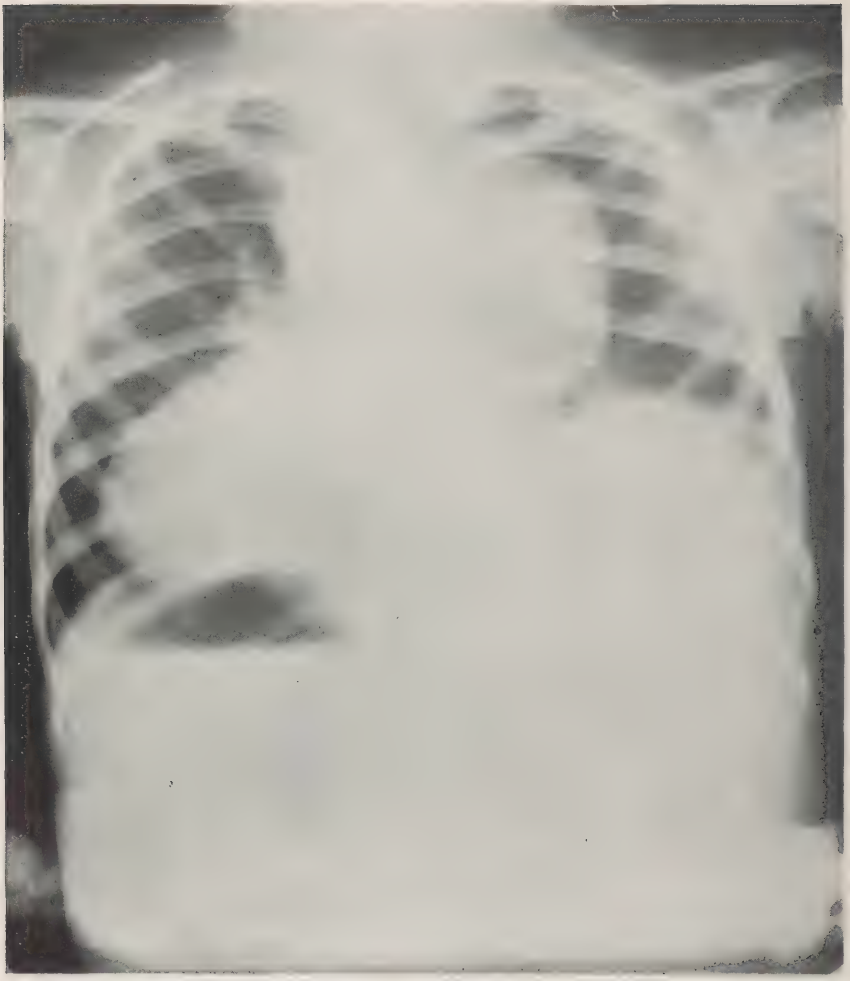


FIGURE 62.—Neoplasm of mediastinum. (These lesions are usually globular in outline, sharply marginated. They may attain considerable size without there being any appreciable symptoms.)

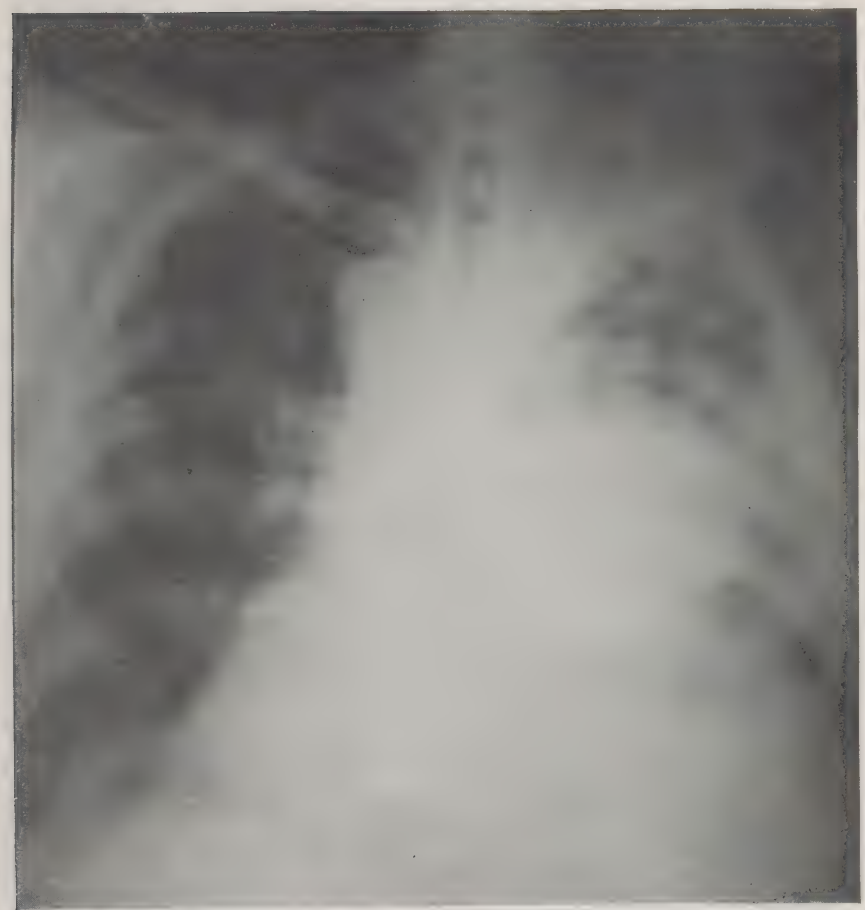


FIGURE 63.—Bronchogenic carcinoma of lung. (Note evidence of atelectasis in addition to "sun ray" infiltration density of tumor.)

(15) Abnormalities in the configuration or diameters of the heart in proportion to the diameters of the thorax. These cases warrant additional studies such as teleroentgenographic projections onto large films and fluoroscopic studies, if possible.

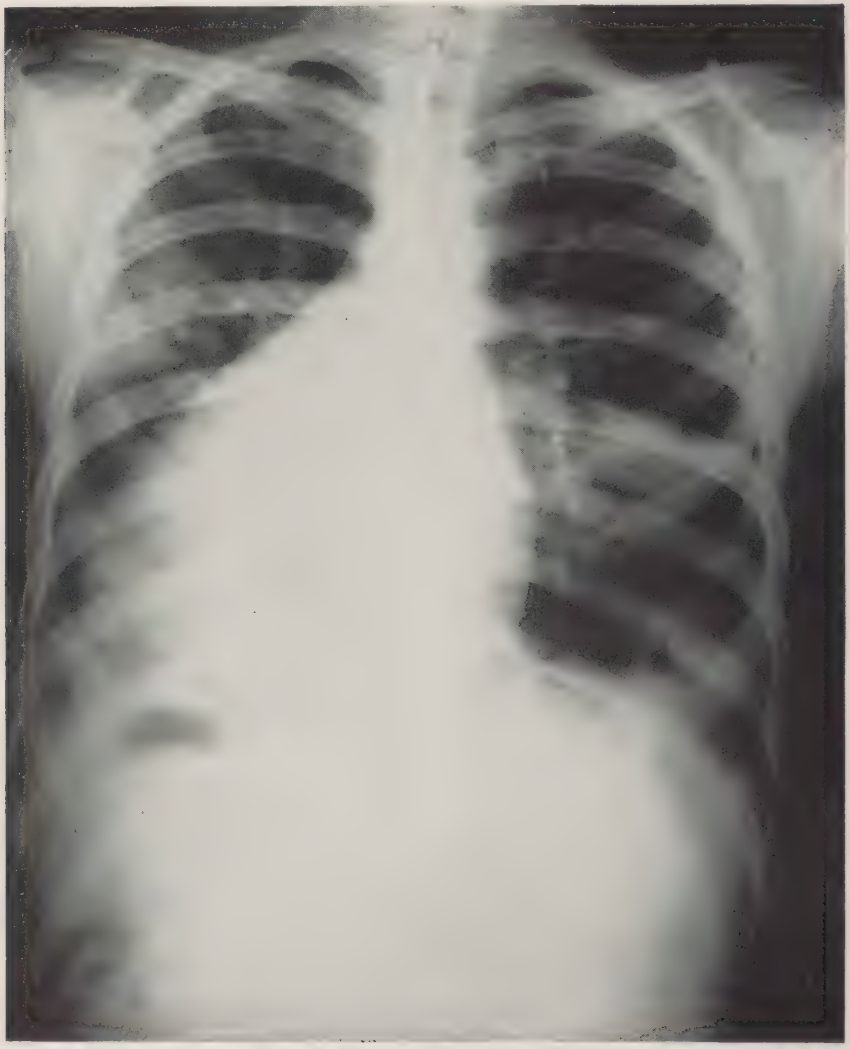


FIGURE 64.—Enlargement of right ventricle. (Note increase in oblique diameter of heart and in this case residua of pulmonary infractions (left auxiliary region and right base).)

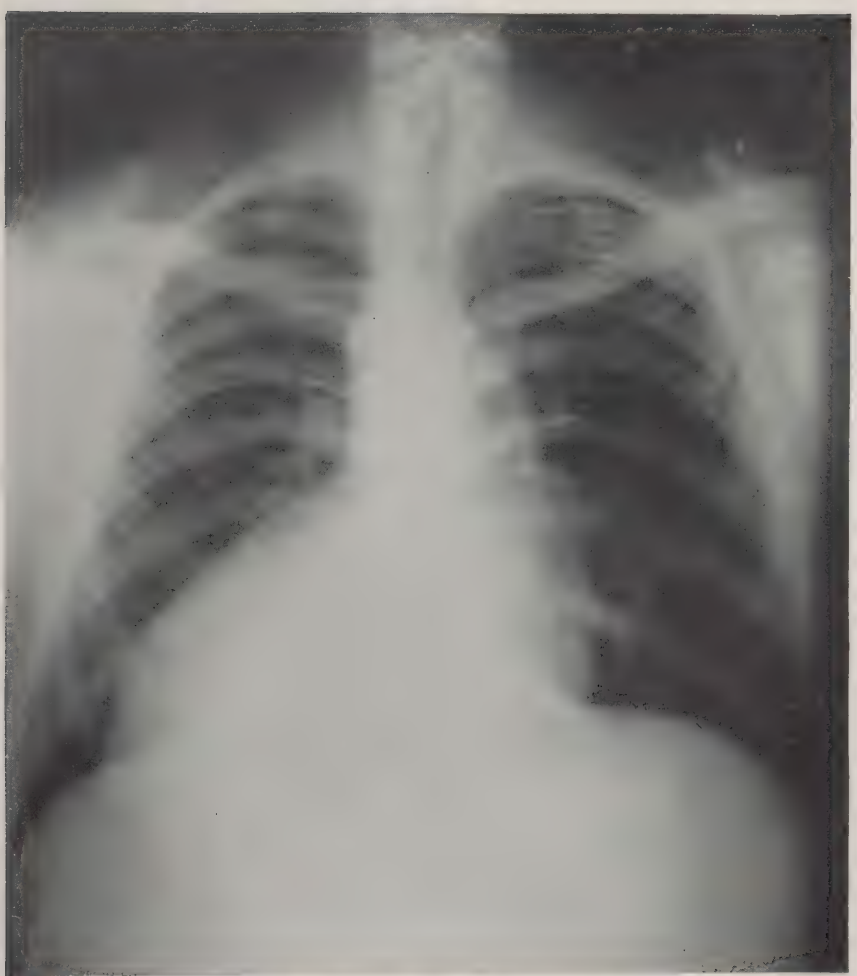


FIGURE 65.—Enlargement of left ventricle. (Note increase in transverse diameter of cardiac silhouette, apex of heart being deviated to left and downward.)

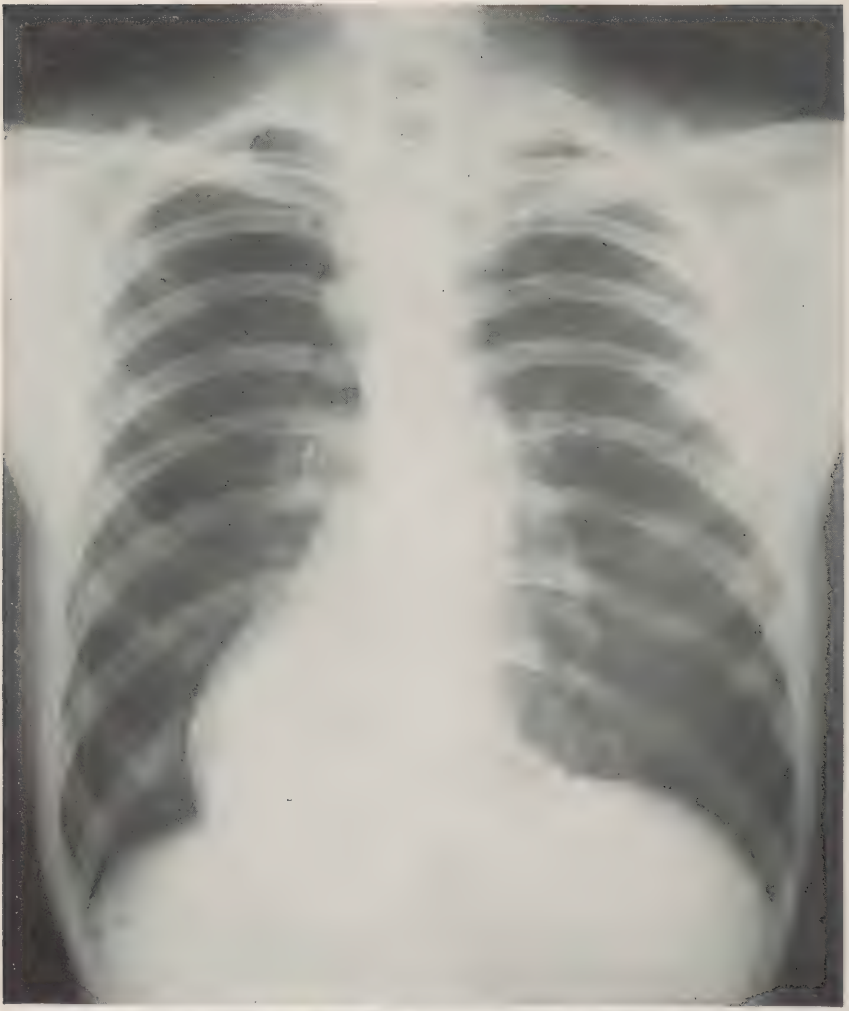


FIGURE 66. Coarctation of aorta. (Note pulsation erosions scalloping along inferior borders of ribs; inconspicuous knob of aorta. Some of these cases will also show a conspicuous left ventricle (increase in the transverse diameter of the cardiac silhouette) and in most of the cases the systolic blood pressure is greatly increased.)

55. Tuberculous lesions.—*a.* Two phases of pulmonary tuberculosis are recognized: the primary or initial phase and the reinfection phase. Because of a different type of bodily reaction to the first versus the second bacterial invasions, certain roentgen characteristics definitely distinguish these two phases.

b. The average prognosis of the primary phase of tuberculosis is quite different from that of the reinfection phase. Unless extensive, a primary lesion usually involutes with calcification and substantial fibrosis. The calcification occurs after necrosis of tissue. Evidence of it simply indicates considerable reaction on the part of the individual and a protective fibrosis is usually found concurrently with it. After retrogression, recurrent activities of these lesions are reasonably unlikely. The type of reaction to a reinfection lesion is usually quite different. Here, fibrosis ordinarily occurs before autolysis, and calcification of the lesion and the type of fibrosis may be only partially protective. Moreover, the mere fact of reinfection signifies inability on the part of the individual to resist the second invasion or extension of a process. Though overwhelming infection or the depletion of bodily reserves may be responsible, further reactivation of reinfection lesions is to be considered as not unlikely. The incidence of breakdown of these lesions is dependent upon the care and the type of existence of the individual, but the relatively poor prognosis of reinfection cases as compared with those of the primary phase might be emphasized by the fact that approximately 30 percent of reinfection lesions require further hospital care following an apparent cure, while no more than 4 percent of primary lesions have shown breakdown, within the age groups of military personnel.

c. The primary phase is characterized by lymph node involvement; it may include one or more pneumonic consolidations. The involved lymph nodes may be located in the cervical region or they may be located in the intermediary zones of the lungs, but they are usually to be found in the hilar regions or in the vertebral gutters. Pneumonic processes are usually located in the hilar or intermediary thirds of the lung fields, though occasionally they are found in the very periphery of the lungs. There may be several pneumonic processes and, in fact, actual miliary lesions may be developed in the primary phase.

d. In contradistinction, the reinfection phase is characterized by an infiltrative process which is essentially concerned with the lung parenchyma or with the bronchi and the peribronchial lymph channels. This phase is usually manifested, therefore, by strandlike densities which extend according to bronchial arborizations and which are

therefore likely to be found in the peripheral third of the lungs. Particularly, if this type of lesion is found in the apices or in the retro-

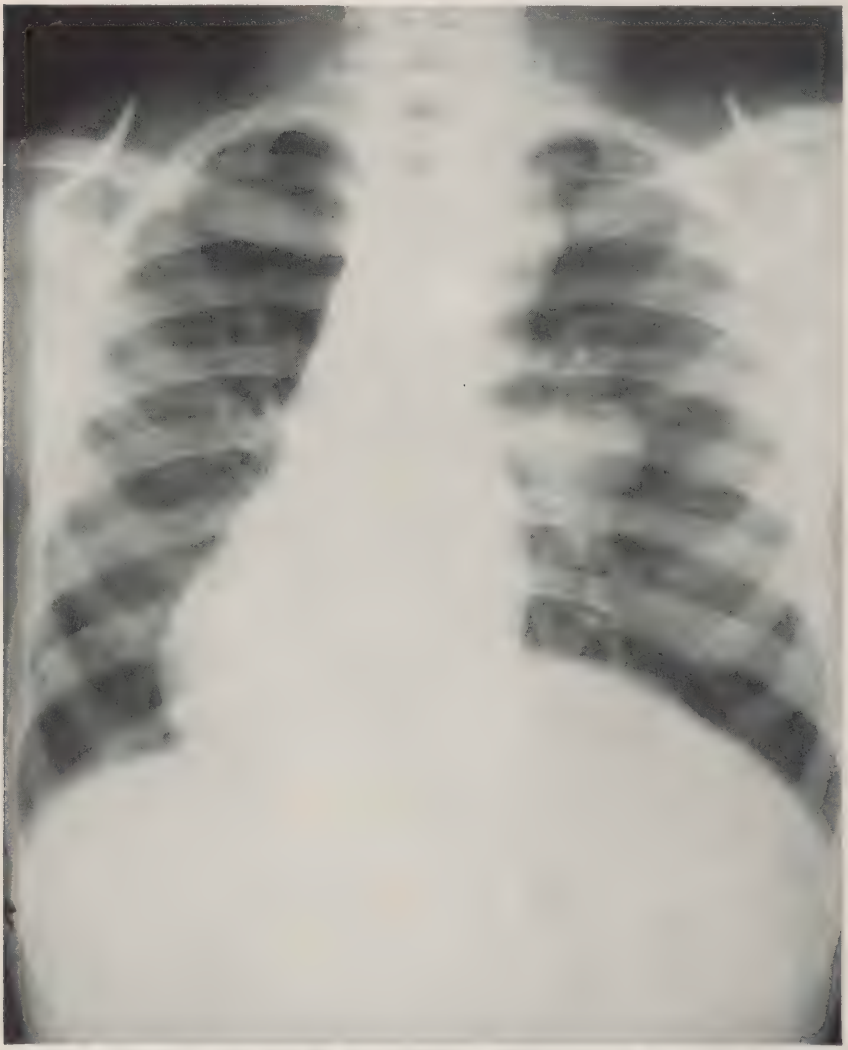


FIGURE 67.—Pulmonary tuberculosis, primary phase. (Note enlarged paracervical and hilar lymph nodes on right side. The dimensions of these lymph nodes plus the fact that there is no evidence of fibrosis or calcification signify activity of the process, though the individual may be fairly active, simply feeling slightly under par.)

clavicular regions, it is most likely that they are manifestations of the reinfection phase.

e. Any evidence of activity of a primary lesion is cause for rejection. Activity may be manifested by a soft tissue density outlining a pneumonic consolidation or by the outline of enlarged lymph nodes. In

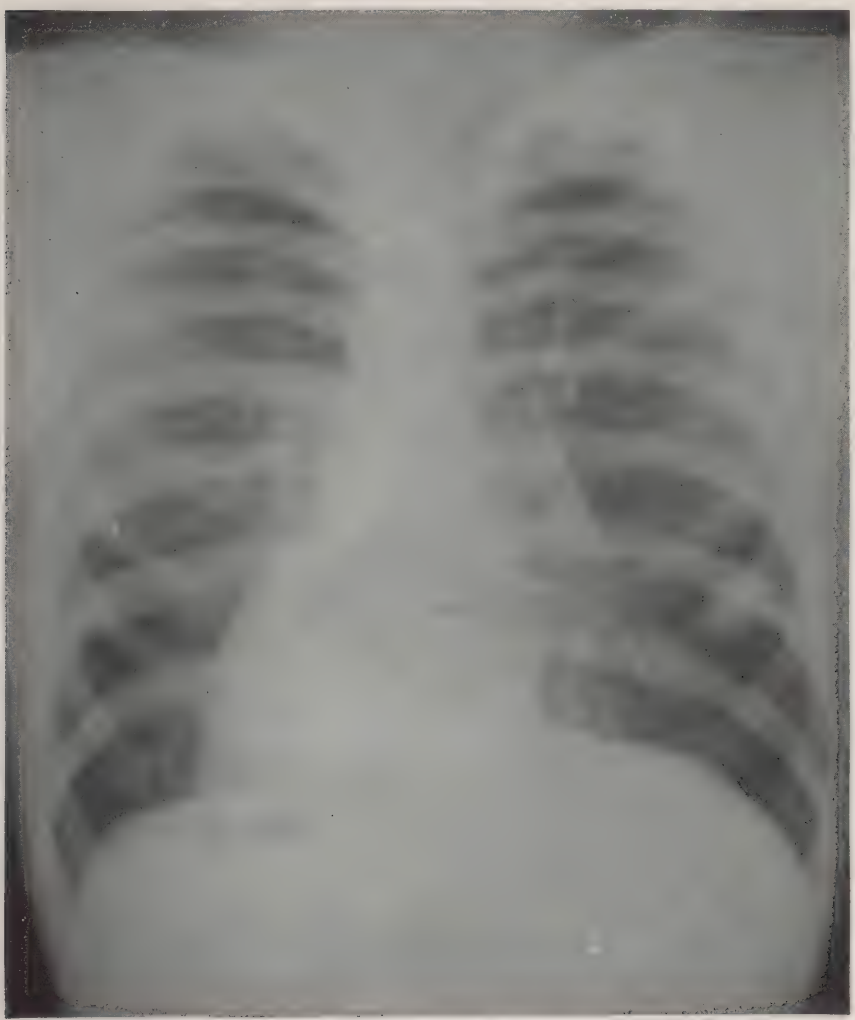


FIGURE 68.—Pneumonic consolidation, primary phase. (Note localized consolidation, right lower lobe. The infection has not yet extended to the lymph nodes in this case. The patient had been steadily active; he was a medical interne whose tuberculin skin tests had been negative until after the finding of this lesion.)

either case, mere stipplings of calcific density should be considered as indication of an unstable lesion and therefore cause for rejection temporarily. Likewise, lesions which consist of a central calcific

density having a periphery of lesser tissue densities (perifocal reaction) should be considered uncertain as to healing and therefore the individual should be disqualified at least temporarily. Actual cavitation might be found during the primary phase: such evidence

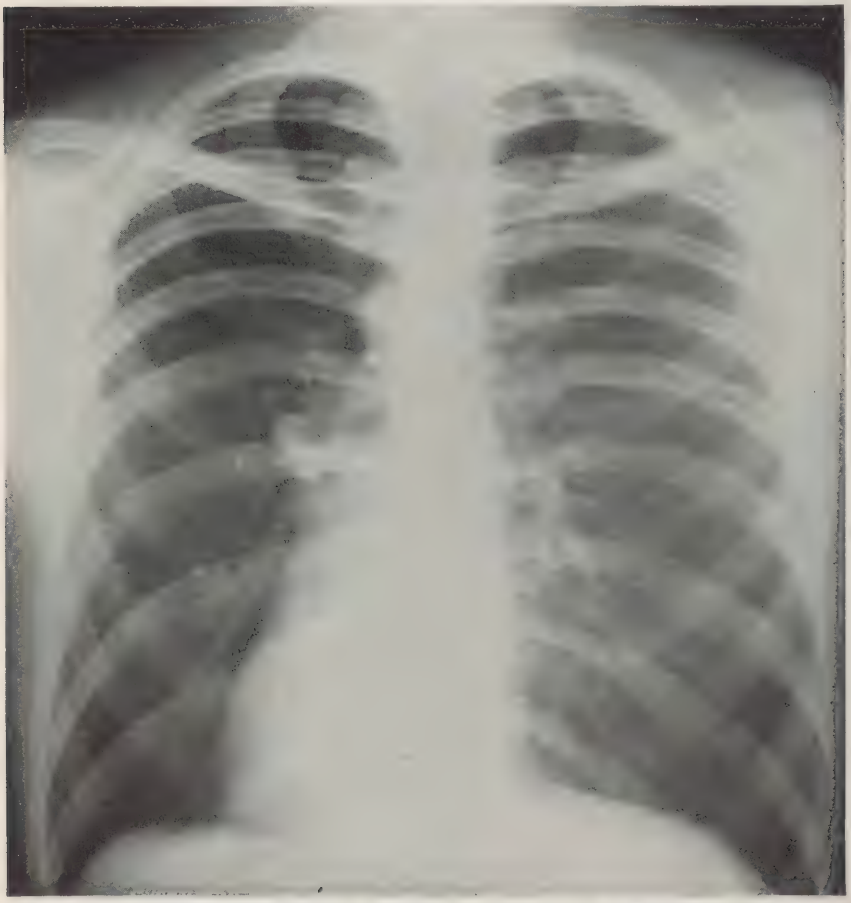


FIGURE 69.—Involuting lesion in lymph nodes. (The number of lesions visualized in this case would not be sufficient to disqualify the individual, but the dimensions of the one or two large lymph nodes in the left hilum and the stippled character of the calcification signify incomplete involution of the process and for this reason the individual should be rejected.)

should be considered indicative of activity and therefore disqualifying. Calcific lesions which are homogenously dense and sharply circumscribed might be acceptable provided their dimensions are not too great and there are not too many of them. In order to provide for uniformity of decisions, arbitrary limits are cited as follows:

there may be as many as 15 of these lesions, 5 being located within lymph nodes and 10 in the lung parenchyma. Those located in the lymph nodes must not be of dimensions greater than 1.5 centimeters.

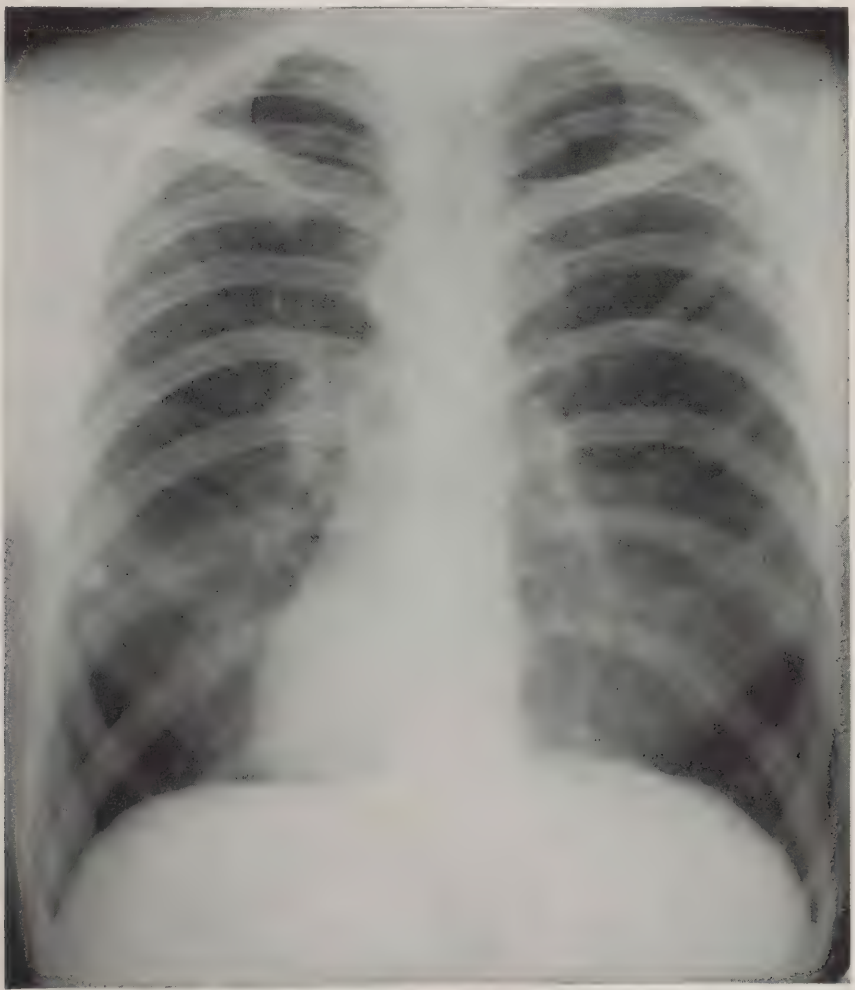


FIGURE 70. Involuting lesion in parenchyma. (Note residual consolidation in lateral aspect of left lower lobe. Large film studies revealed a central calcification with a peripheral fading of the density. Such lesions may continue to retrogress, provided suitable rest and nourishment are supplied, or these lesions may suddenly progress into an extensive reinfection type of tuberculosis. Therefore, these findings should serve to disqualify for the present.)

Of those located in the lung parenchyma, no more than one may be as large as 1 centimeter in greatest dimension while the others must not be greater than 0.5 centimeter in greatest dimension. These measure-

ments may be estimated on the basis of studies made by reduction roentgenography (that is, using the miniature films), but the measurements pertain to actual size as they would be projected teleroentgenographically onto 14- by 17-inch films. These studies should be

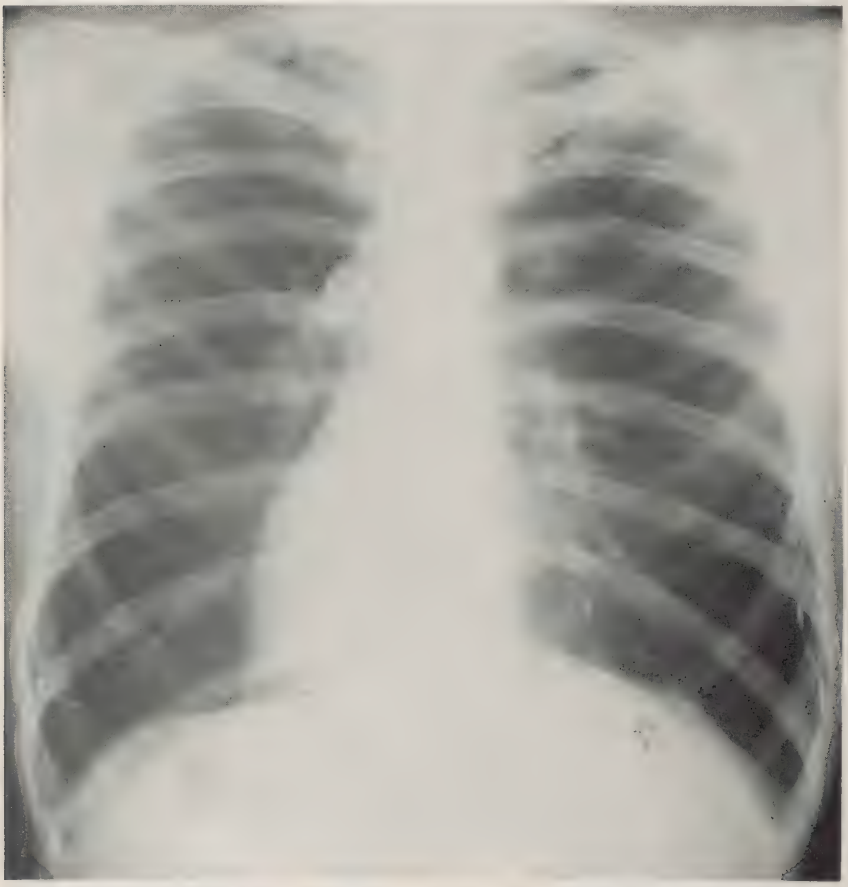


FIGURE 71.—Disqualifying single primary lesion. The character of the reaction processes in this case appears to be substantial but because of the dimensions of the lesion, this case should be disqualified.

accomplished wherever there is uncertainty because of the factors of distorted proportions and the reduction inherent to the miniature film procedure.

f. Any evidence of a reinfection lesion must be considered basis for disqualification. Later acceptance of an individual having very minimal lesions might be possible, provided after a period of 6 months

there is found to be neither progression nor regression of the lesion. Such final acceptances must be limited to a very small percentage of these cases for the extent of these lesions must not exceed in dimensions a volume of lung parenchyma such that, when projected onto

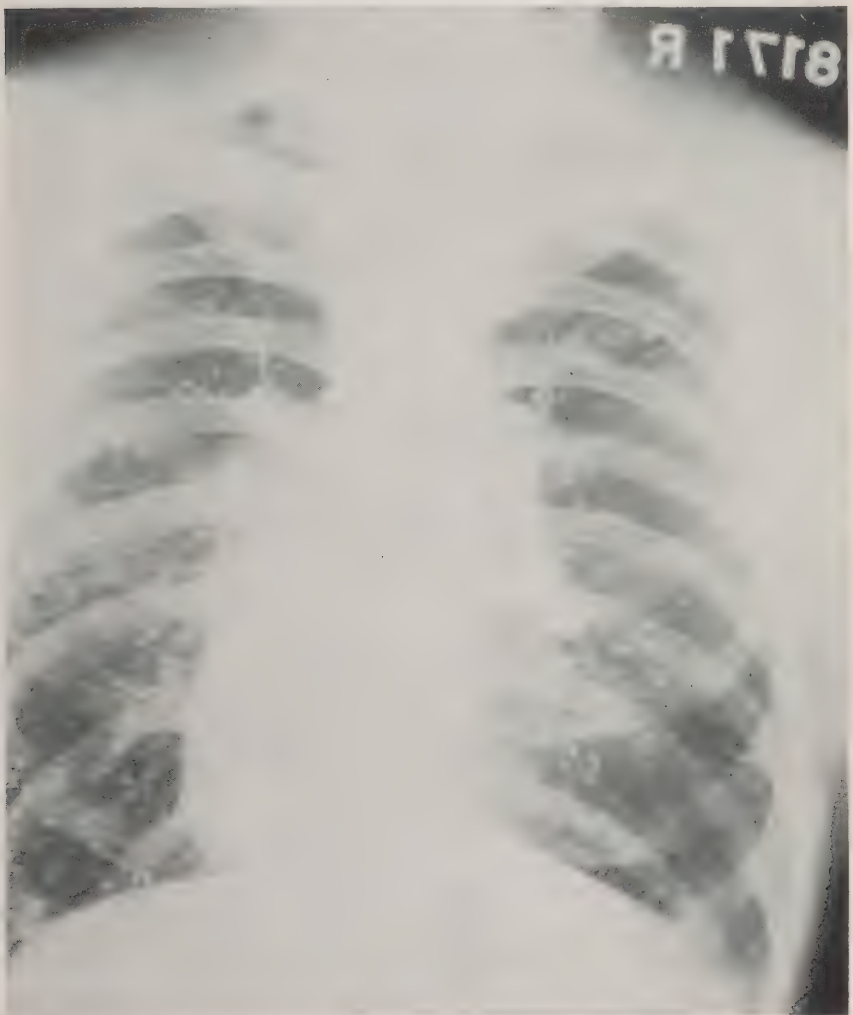


FIGURE 72.—Multiple primary lesions. Though the lesions in this case appear to be healed, because of there being more than 15, the individual should not be accepted.

a standard 14- by 17-inch roentgenogram, the involvement will be confined to an area no greater than 5 square centimeters. Reinfection lesions are characterized by strandlike densities. Lymph node en-

largements are not a part of their picture. Their pattern may appear merely as exaggeration of the normal pulmonary markings or as nodulations and definite consolidations. Misinterpretation of promi-

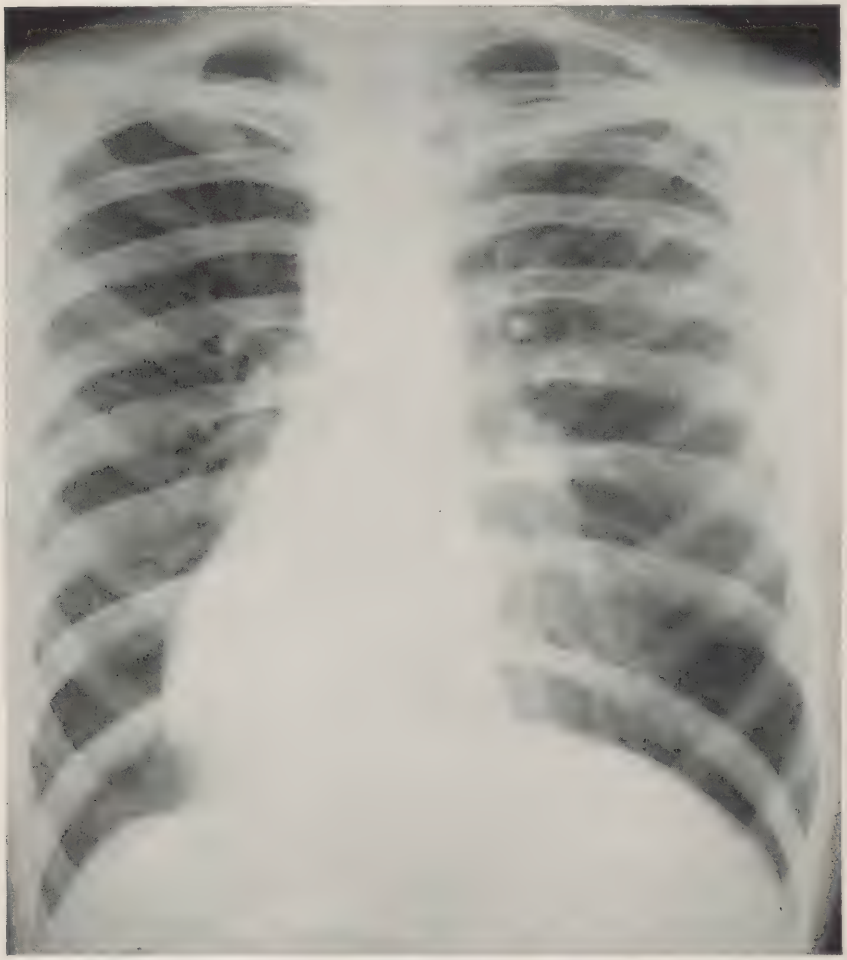


FIGURE 73.—Pulmonary tuberculosis, reinfection phase, minimal. Note the calcific density in the right hilum. This likely represents the primary lesion. The infiltrate in the lateral aspect of the right upper lobe is the beginning reinfection lesion. When projected onto a 14- by 17-inch film, this particular lesion measured approximately 5 square centimeters—the maximum area dimensions permitting reconsideration after a period of 6 months.

nent pulmonary markings, due to underexposure of the roentgenogram or to movements of the pulmonary vessels, must not be confused with tuberculous processes. In contradistinction, reinfection lesions

are generally localized; the fuzzy markings which depict them are not usually distributed uniformly throughout the entire lung fields, except in extreme degrees which would be readily recognized. Reinfection lesions usually follow one or another bronchial distribution

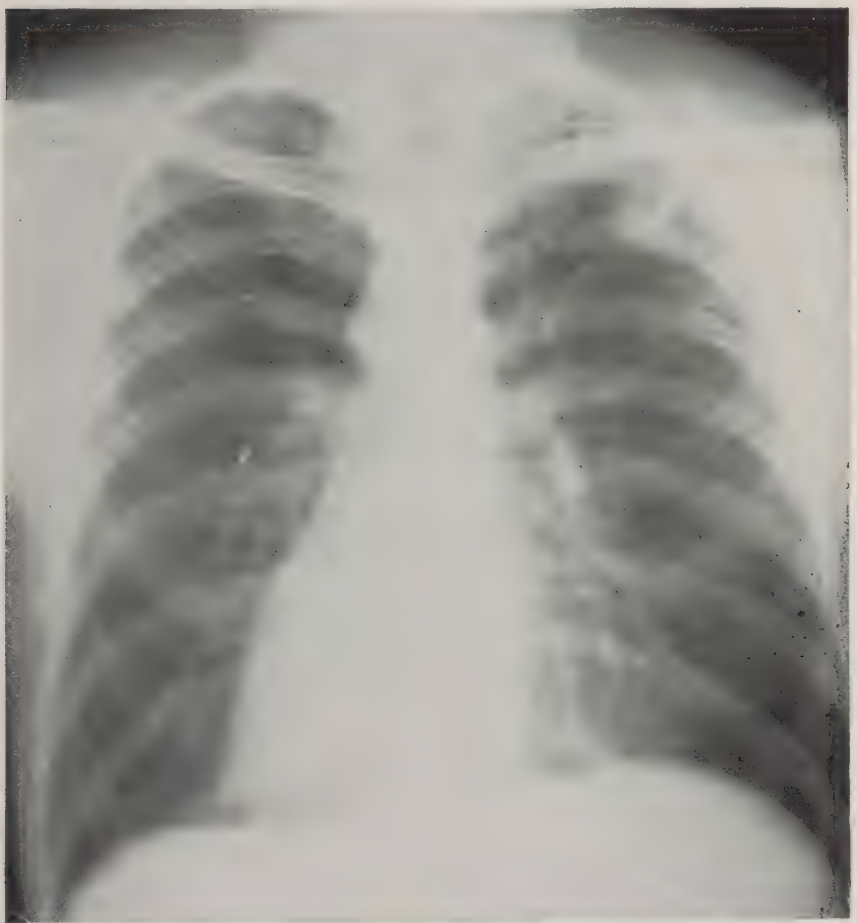


FIGURE 74.—Typical reinfection lesion. Note the location of the infiltrates—the peripheral aspect of the upper lobe, the infraclavicular region. The fuzzy pattern of this infiltrate suggests activity and the extent of involvement compels disqualification without reservation.

and therefore, even in their earliest stages, they should be identified after glancing over other portions of the lung fields and noting the more delicate pattern of the normal lung as compared with the coarsened and fuzzy pattern of an involved portion.

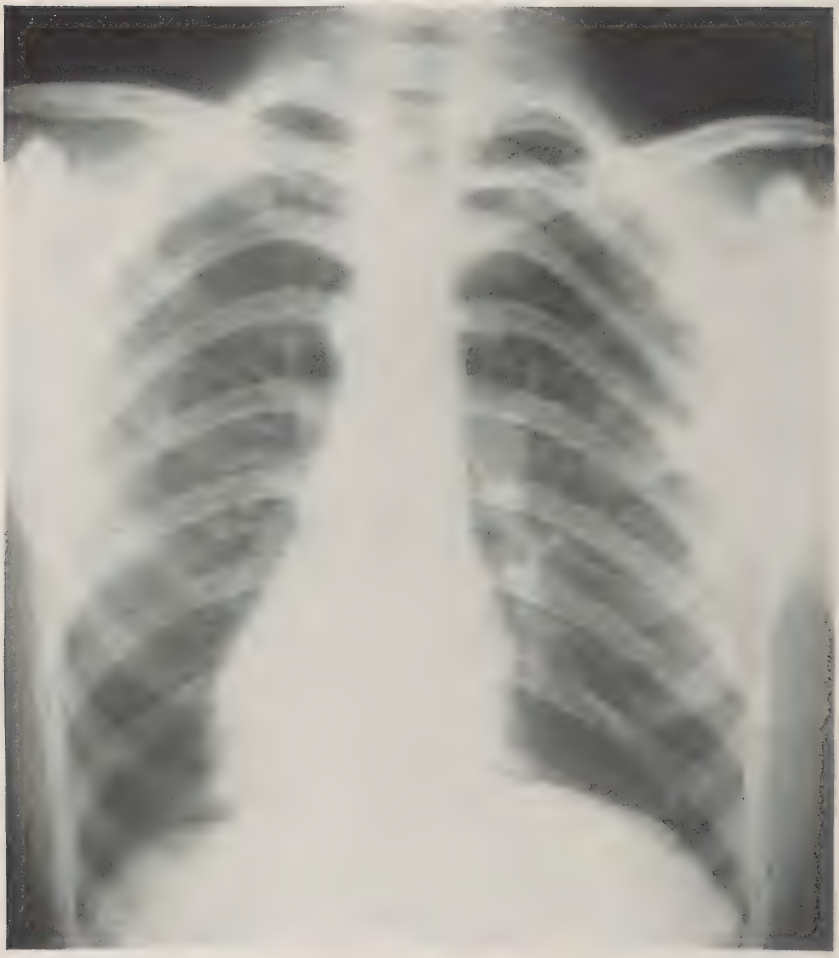


FIGURE 75.—Very early stage of reinfection tuberculosis. (This study emphasizes the importance of certain inconspicuous lesions. Note very delicate arborization in axillary portion of right lung. This should have been noted if care had been taken to follow a definite sequence of analysis. The contraction of the ribs in the region of the lesion would have been noticed an then, doubtless, significance would have been placed in the delicate arborization of pulmonary markings found in the peripheral third of the right middle lung zone. Note rapidity of break-down during succeeding 8 months as visualized in figure 76.)

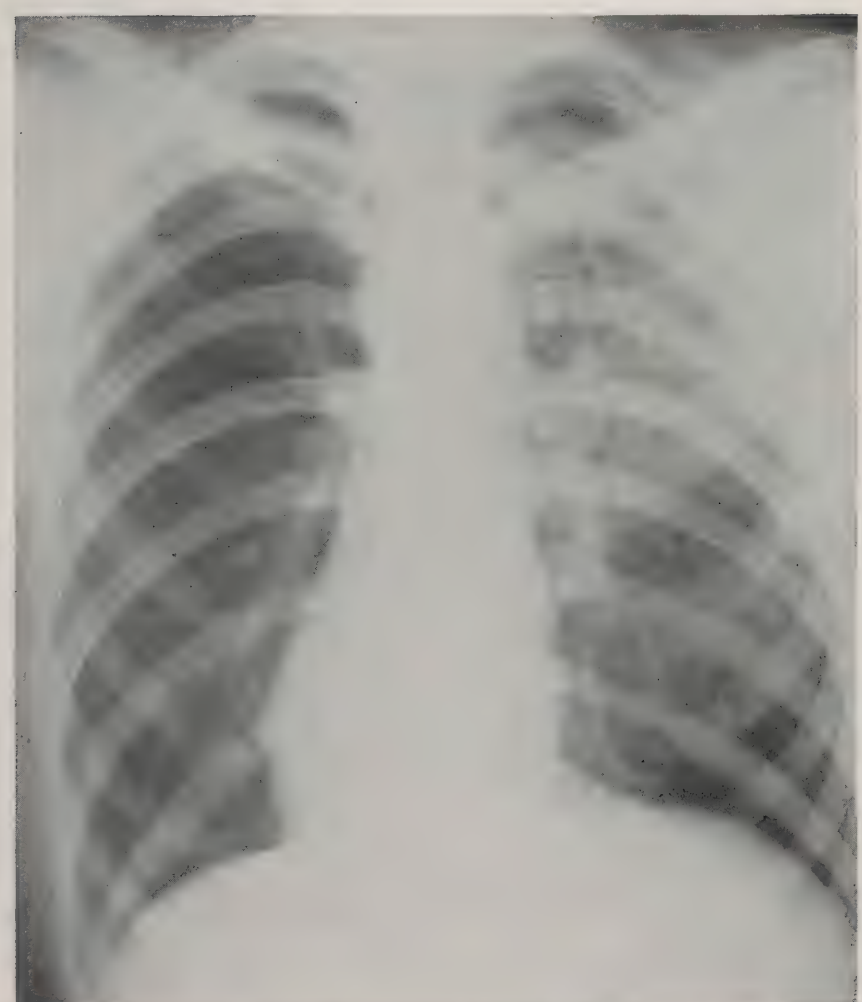


FIGURE 76.—Reinfection tuberculosis, moderately advanced. (This study shows how rampantly an active tuberculous process may progress under conditions of military life.) (See fig. 75.)

g. Cavitation may occur either during the primary phase or during the reinfection phase. Regardless of the size of any cavities, they should be considered cause for rejection. However, rather than misin-

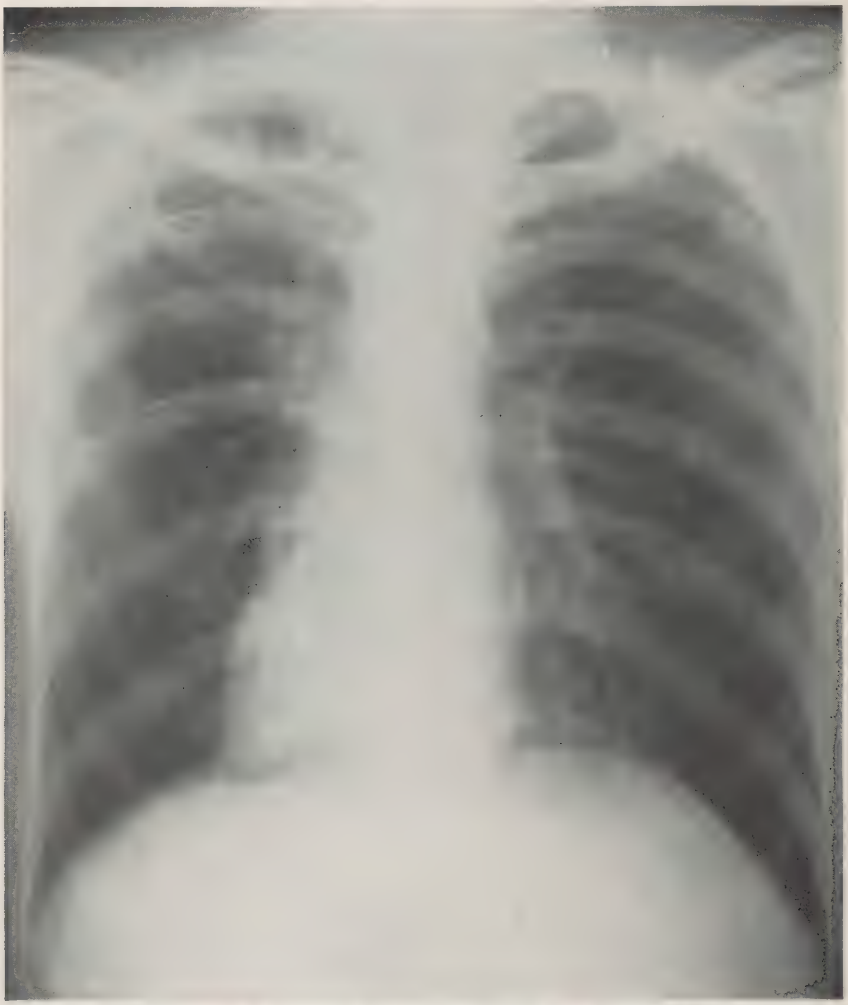


FIGURE 77.—Cavitation in pulmonary tuberculosis. (Note that complete encirclement of this cavity is evident by a definite wall. The location of the cavity is characteristic, being in the peripheral third of an upper lobe. The absence of a fluid level and the thin wall depict the cavity as of tuberculous nature.)

terpret superimposed pulmonary markings which may present the appearance of cavitation, it is always important thoroughly to visualize a cavity by obtaining projections from various angles; utilizing

obliques, laterals, and stereoscopic studies, and films of standard dimension, if necessary.

h. Mere evidence of a pleural cap (that is, thickening of the pleura over the apex of either lung) or of diaphragmatic tentings should

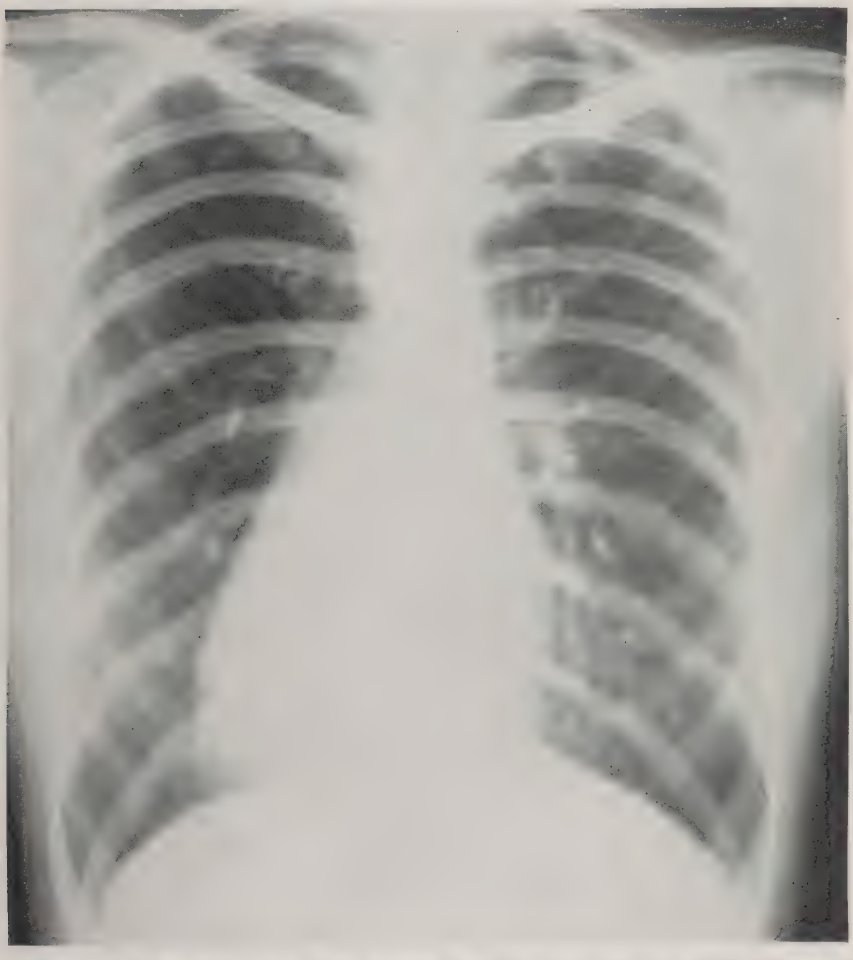


FIGURE 78.—Apical caps. (The heterogeneous densities which cap the apical portions of both upper lobes are partly due to thickened pleurae. Whereas such evidence alone is of no importance, an underlying infiltrate as found in the left upper lobe of this case (both above and below the left clavicle) is basis for disqualification.)

not be considered cause for rejection unless there are found, extending from either of them, definite parenchymal lesions. Then, evaluation of the findings should be based upon identification of the phase of the disease process. Widespread pleural thickenings might be considered

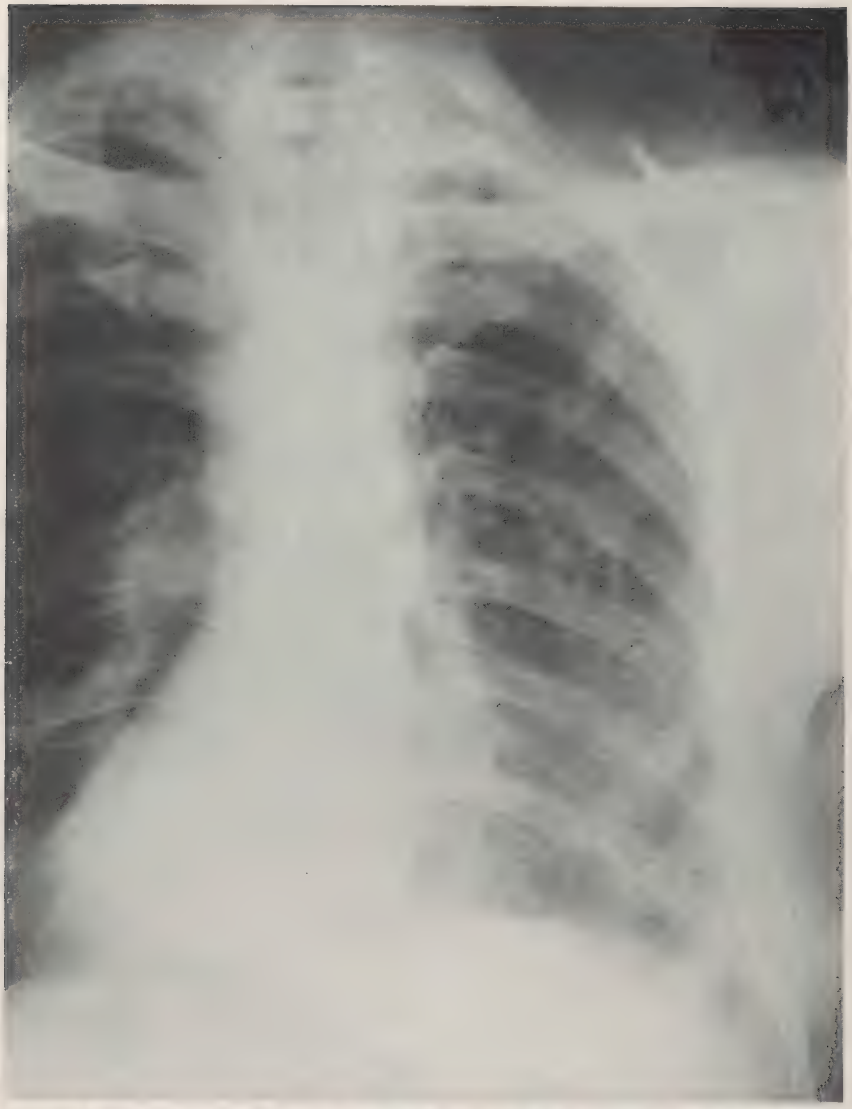


FIGURE 79.—Diaphragmatic tentings and calcification of pleura. (Mere evidence of strands extending from the diaphragm or of calcifications in the pleurae such as visualized in this case should not serve to disqualify. However, careful search should be made for any walled off pockets or for evidence of adhesions to the pericardium, which findings should disqualify.)

cause for rejection, provided their etiology is not attributable to a nontuberculous episode and provided the thickenings of the interlobar septa or of the diaphragmatic or parietal coverings are such as possibly to obscure a focus of dormant infection. Calcifications in the

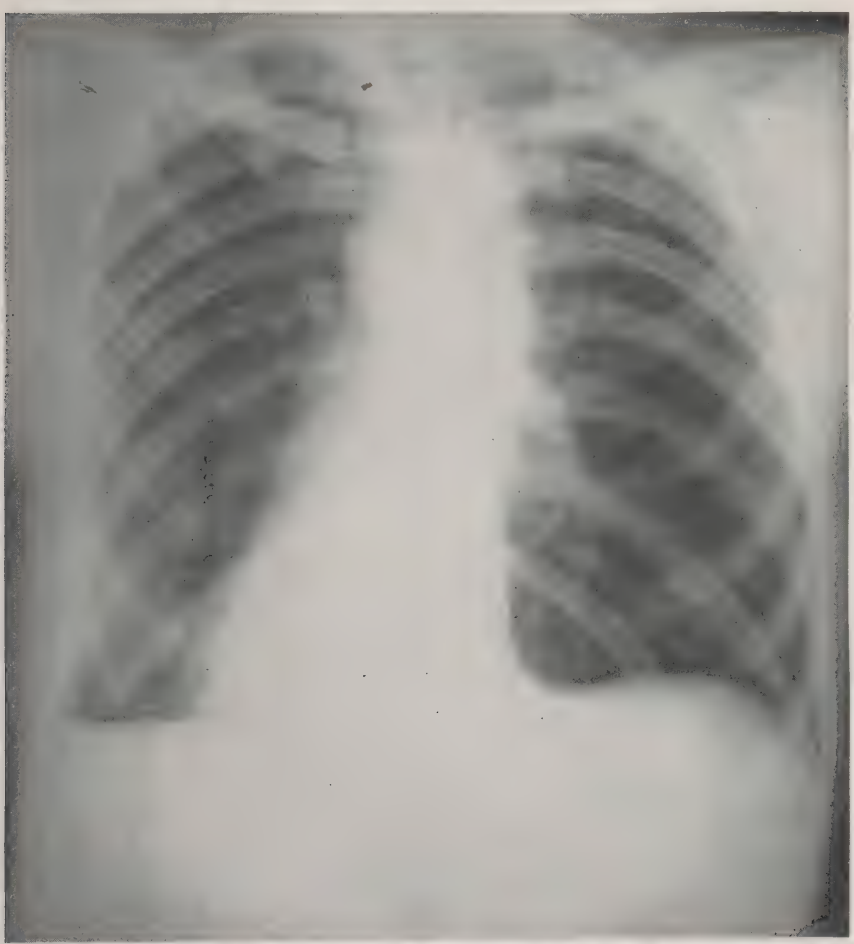


FIGURE 80. Obliteration of diaphragmatic sulcus. (This case shows considerable pleural thickening. Studies should be made to rule out the possibility of free fluid or walled off pockets of inflammatory media. If there is no such evidence, these findings should not disqualify.)

pleurae are not considered to be of the same degree of importance as calcifications in the lung parenchyma or lymph nodes. Unless parenchymal lesions are found extending from them, acceptance or rejection of such cases should be based upon the extent of the pleural involvement as above described. Obliteration of the diaphragmatic

sulci because of pleural thickening may not be of serious importance or basis for rejection. In such cases a twofold assurance should be established: assurance that ample margin of vital air capacity remains: and assurance that there are no concealed pockets or empyema (that is, dormant or active inflammatory media).

i. The above descriptions have been limited to more or less borderline cases where some doubt might exist as to whether an individual should be accepted or disqualified. Moderately advanced or far advanced lesions of reinfection tuberculosis would likely prevent any individual from being sufficiently active that he would be examined for service in the Army and in the case of those already in the service, the diagnosis would doubtless have been established during earlier stages. At least, these more developed processes would readily be recognized and there should be no doubt as to proper handling of them. Miliary lesions, whether they present evidence of instability or of having healed, must be considered disqualifying. With considerations of responsibilities on the part of the Government, not only prognosis and the probabilities of break-down must be considered but also the possibilities of claims being made later merely because of the presence of lesions which are likely to become known to the individual.

j. In general, a disqualification which is based upon a diagnosis of a reinfection phase of tuberculosis will usually be permanently effective, whereas a disqualification which is based upon a diagnosis of an unstable primary lesion provides for later reexamination and possibly later acceptance. It must be emphasized that the clinical aspects of any doubtful cases must be considered. The criteria listed pertain to cases where explanations cannot be based upon pyogenic pneumonic processes or a background of other infections. Table II emphasizes acceptable versus unacceptable criteria.

TABLE II

Phase	Acceptable	Unacceptable
Primary		
Definitely active		(1) Pneumonic consolidation, isolated or few (usually located in hilar or mid zones; possibly lobar or miliary). (2) Enlarged lymph nodes (usually located in hilum; possibly paratracheal, midlung zones, or cervical). (3) Cavitation.
Unstable		(1) Residual parenchymal consolidation (possibly showing central calcific density but a periphery of lesser densities fading into those of normal parenchyma). (2) Stippling of calcific densities (either in parenchymal lesions or in lymph nodes).
Stable	(1) Parenchymal nodulation (usually calcific in density), provided there are no more than ten such and provided no more than one of these has a diameter as great as 1.0 centimeter, the others having no larger diameter than 0.5 centimeter. (2) Residual lymph node densities (calcific), provided there are no more than five such and provided their diameters are no greater than 1.5 centimeters. (3) Pleural cap, without underlying parenchymal lesion of significance.	(1) Parenchymal nodulations, multiple, more than ten in number, or if the diameter of any one is greater than 1.0 centimeter or if more than one is larger than 0.5 centimeter. (2) Lymph node densities, multiple, more than five in number or if a diameter of any one is greater than 1.5 centimeters.

TABLE II—Continued

Phase	Acceptable	Unacceptable
Primary—Con.		
Stable—Con	(4) Diaphragmatic tenting without overlying parenchymal lesions of significance.	
Reinfection		
Definitely active		(1) Hazy, strandlike, and diffusely nodular densities in the lung parenchyma. (2) Bronchopneumonic or lobar consolidations. (3) Cavitations. (4) Pleural effusion. (5) Pneumohydrothorax.
Unstable		(1) More or less sharply demarcated strandlike densities infiltrating a volume of lung parenchyma which when projected onto a standard 14- by 17-inch roentgenogram would measure more than 5 square centimeters. (2) Pleural thickenings of such degree as possibly to obscure a dormant infection.
Questionable stability.	Sharply demarcated strandlike densities infiltrating a volume of lung parenchyma which when projected onto a standard 14- by 17-inch roentgenogram would measure less than 5 square centimeters and which has shown no progression or regression in size or appearance after an interval of 6 months.	Sharply demarcated strandlike densities, as just described, but involving less volume of lung parenchyma. Such cases should be restudied after an interval of 6 months.

56. Confusing evidence.—*a*. Particularly when studying films directly rather than stereoscopically, a number of normal densities may serve to obliterate important detail of pathology. Occasionally these densities have been misinterpreted and reported as actual pa-

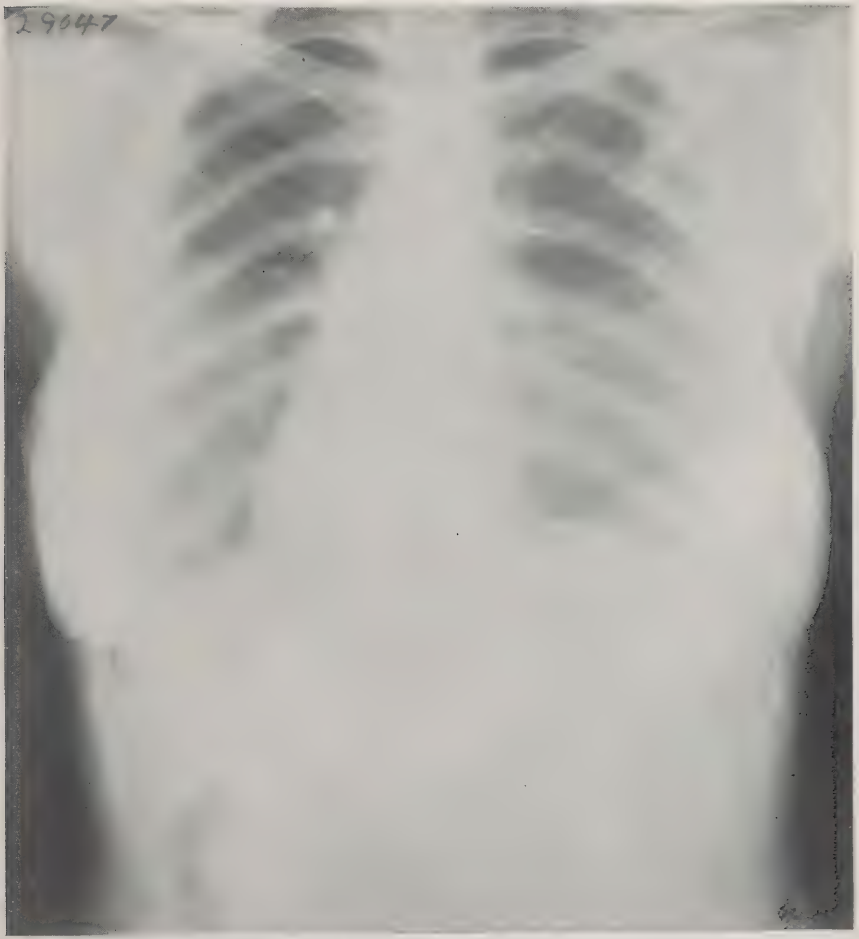


FIGURE 81.—Cervical rib, right.

thology—a very serious error not only because the services of the individual may thereby be lost to the Government but also because such errors may impose a psychic shock upon the individual unnecessarily. Intelligent identification of the densities in the upper portions of the thorax is especially important since lesions of tuberculosis are so characteristically located in the apices of the lungs.

b. In case the head is insufficiently extended during the exposure, there may be superimposition of the densities of the chin or cheeks upon the upper lung fields; if the head is overextended, the density of the occiput will be superimposed. These relations would prevail

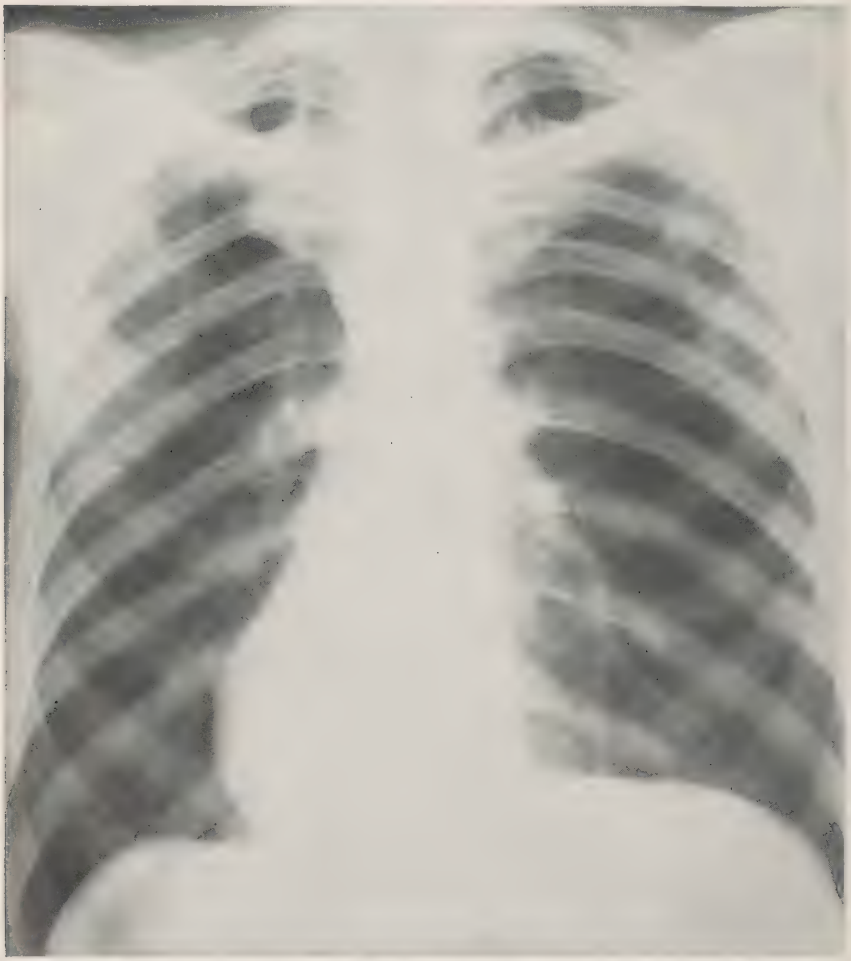


FIGURE 82.—Conspicuous neck folds. (In this particular case a tuberculous infiltrate was almost overshadowed by the fold in the left paratracheal regions.)

particularly if the focal spot of the X-ray tube is alined to a high level with respect to the chest.

c. The densities of cervical ribs or of neck folds may likewise lead to confusion.

d. As previously emphasized, mere thickening of the pleura over the apices (pleural cap) should not by itself be considered basis for rejection. Post mortem studies have indicated a very substantial degree of fibrosis in most of these lesions. Occasionally, there are

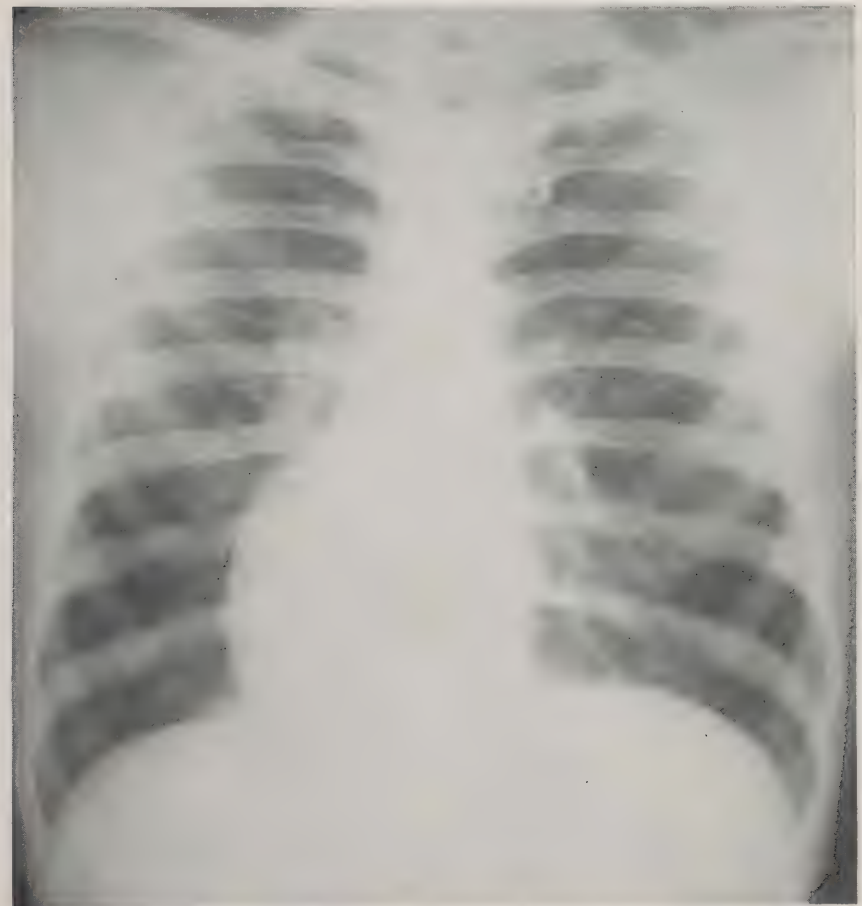


FIGURE 83.—Azygos septum. (Note crescentic outline of azygos septum. These septations are always located in the apical portion of the right thorax. They occur in approximately 10 percent of individuals and must not be misinterpreted as a tuberculous infiltrate.)

associated with them definite parenchymal lesions which may not be clearly discernible because of the density of the pleural cap itself. Therefore, particular search must be made for underlying parenchymal lesions in all such cases.

e. The septation produced by the azygos vein is not infrequently visualized and occasionally the innominate or subclavian vessels may

cast a shadow. These densities are likely to be more conspicuous on the miniature film than on the standard 14- by 17-inch film because of the relatively short focal screen distance (resulting in magnified distortion) and the subsequent photographic reduction (resulting in

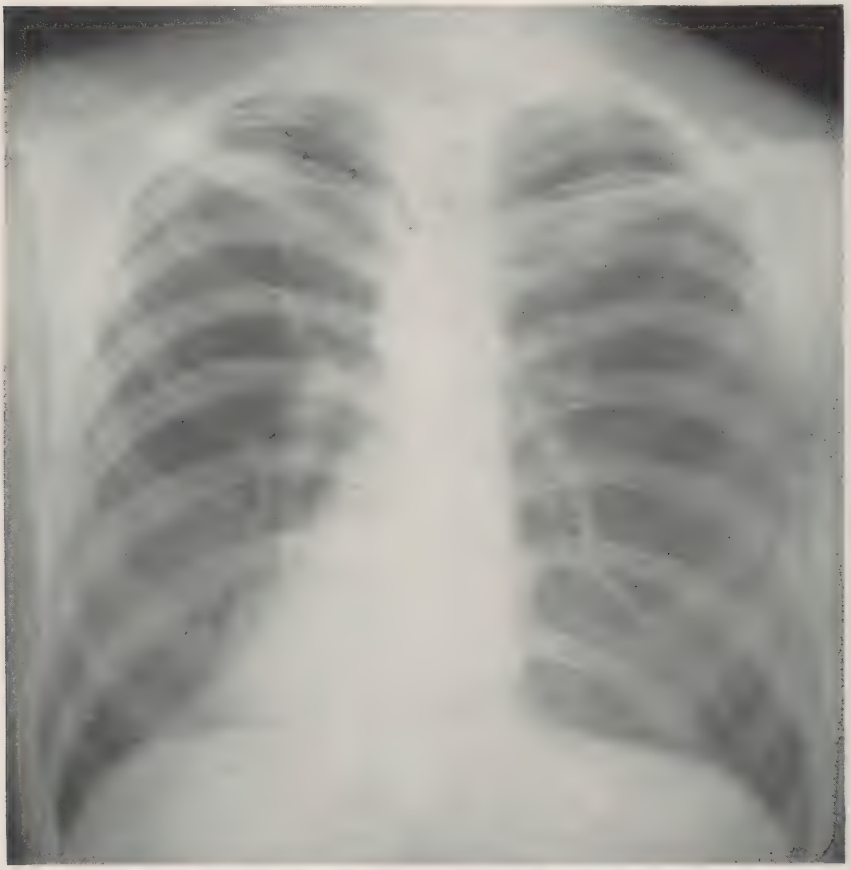


FIGURE 84.—Visualization of subclavian vessel. (Note ribbonlike density in left apex outlined by arrow markings. When there happens to be sufficient contrast provided by air space about the greater vessels, they are visualized as in this case.)

sharpening of the detail). These densities must not be misinterpreted as tuberculous infiltrates.

f. Particularly if a pocket of air surrounds a soft tissue tumor such as a papilloma or even a normal nipple during the exposure, a conspicuous density may be produced, presenting the appearance of a pneumonic consolidation.

g. A bifid rib may produce an outline which might be interpreted as cavitation.

h. Calcifications in costal cartilages or in the pleurae may be erroneously interpreted as calcifications within lymph nodes or in the lung parenchyma.

i. When located in the region of the arch of the aorta, enlarged lymph nodes may not be recognized. In the postero-anterior projec-

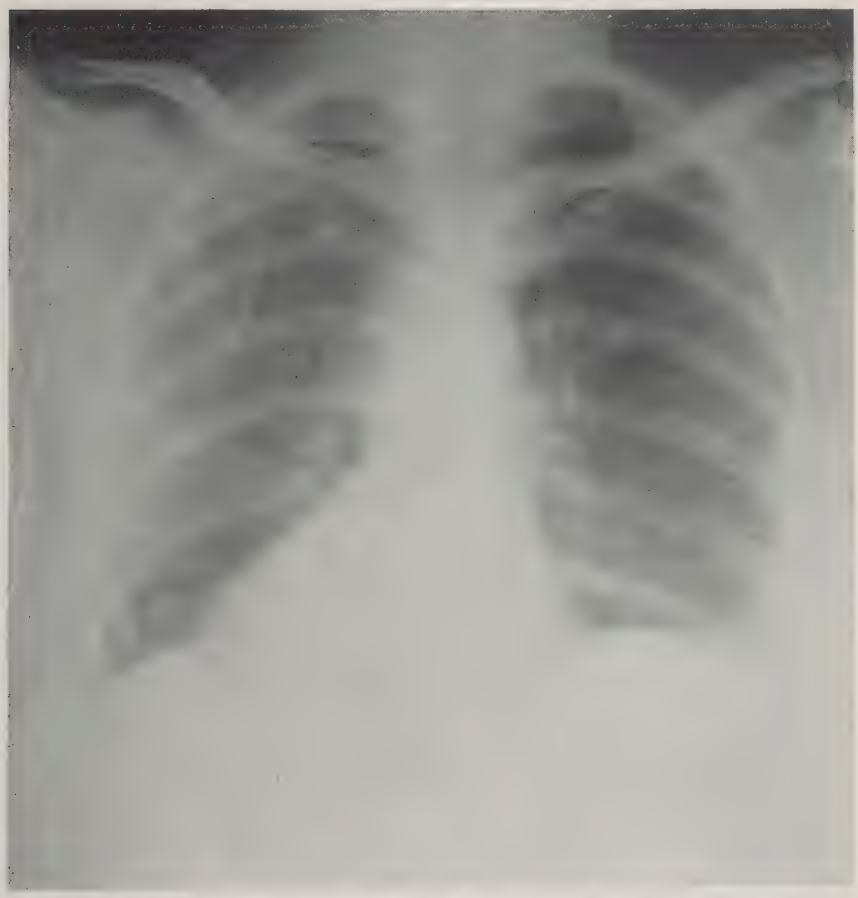


FIGURE 85.—Superficial papilloma presenting appearance of pneumonic consolidation. (Note spherical density in left lower thorax. Lateral projections established the fact that this density was produced by a superficial papilloma.)

tion they may present the appearance of a distorted or widened "knob." Considering the age of most candidates for the service, it would be rare that arteriosclerosis should be encountered or that rotation of the arch might be explained on any other basis. Therefore, oblique and lateral studies should be made on all such cases, in order to provide for the separation of the mediastinal densities and

to visualize more clearly any enlarged lymph nodes which might be located in the hilar regions proper or in the vertebral gutters or the retrosternal regions.

j. Apparent tentings of the diaphragm may actually represent strands of pleural septa, particularly as concerned with the inferior

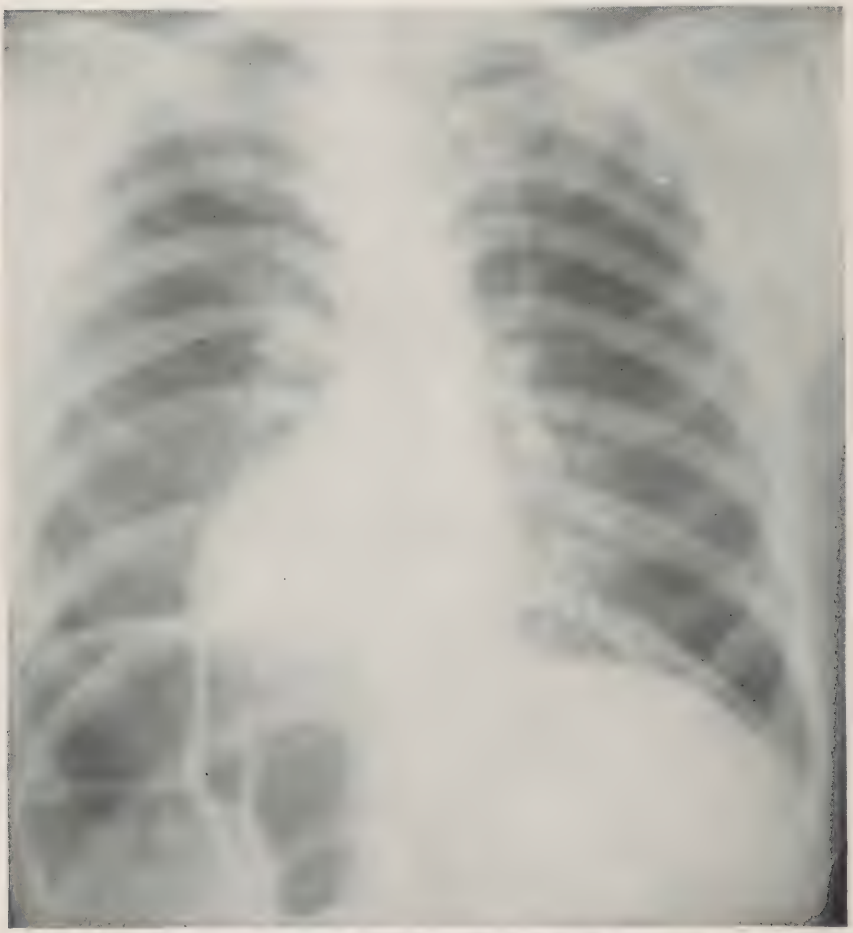


FIGURE 86.—Bifid rib. (Note abnormal appearance of anterior portion of left third rib. Occasionally, these bifurcations are interpreted as cavities.)

accessory lobes (which are present to some extent in 40 to 50 percent of individuals).

k. Platelike atelectases are occasionally seen. They may present the appearance of a tuberculous infiltrate. They should be considered where the densities are of a crescentic or flattened pattern—

versus the more arborized pattern of the tuberculous infiltrate. Such cases warrant reexaminations following a period of deep breathing. If these studies reveal a reduction in their size or a disappearance of the densities, the individual should not be disqualified. Occasionally,

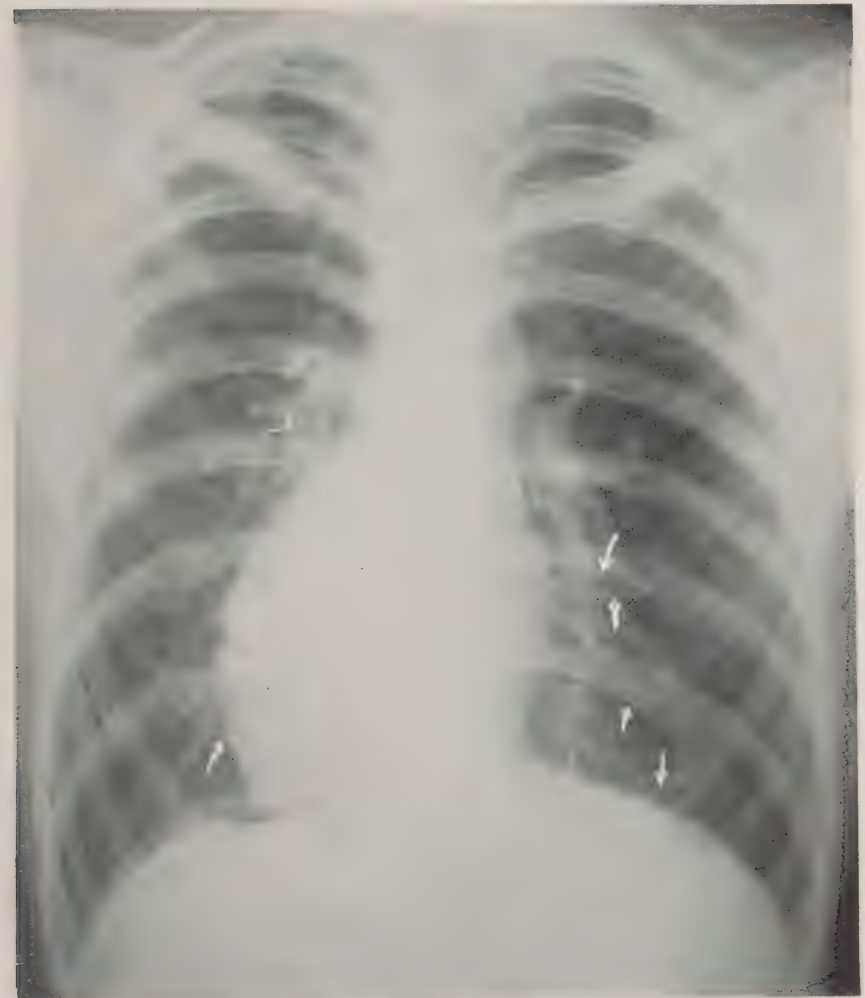


FIGURE 87.—Calcification of costal cartilages. (These calcifications should be recognized because of their alinement to the borders or the axes of the ribs.)

these localized atelectases are produced because of compression phenomena due to large bullae or blebs. In such cases they should be made more conspicuous after deep breathing and the individual should be disqualified.

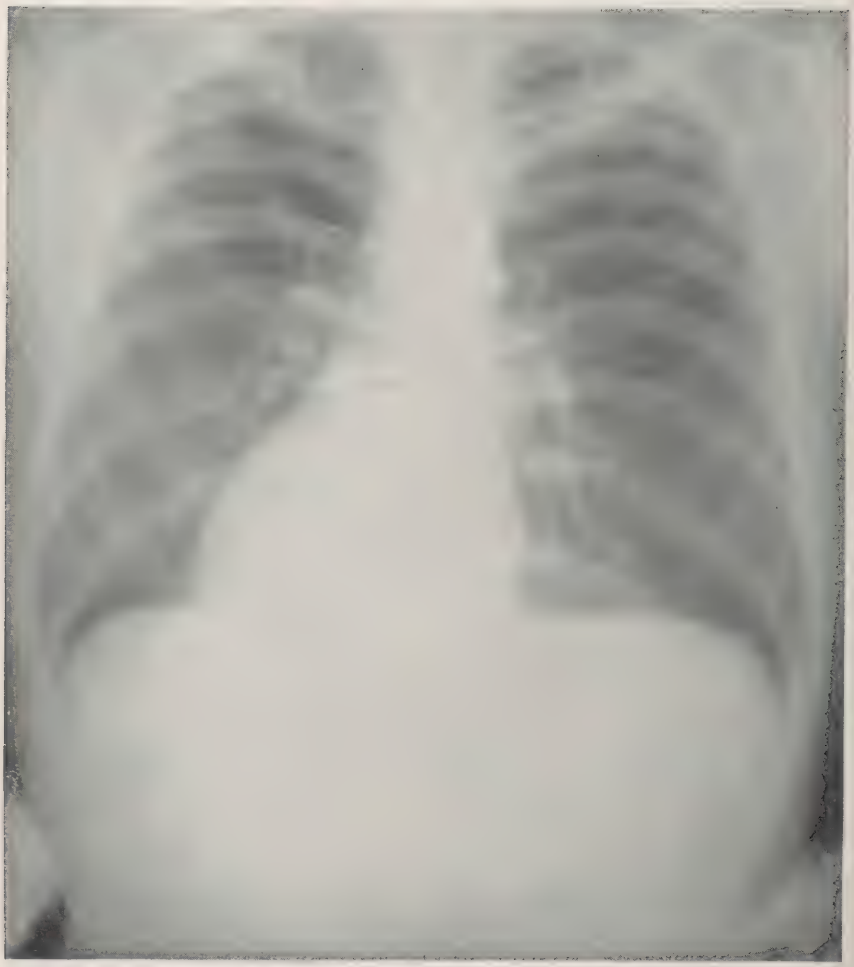


FIGURE 88. Retrosternal lymph node. (In the postero-anterior projection, the outline of this lymph node is partially superimposed upon the density of the aorta.)

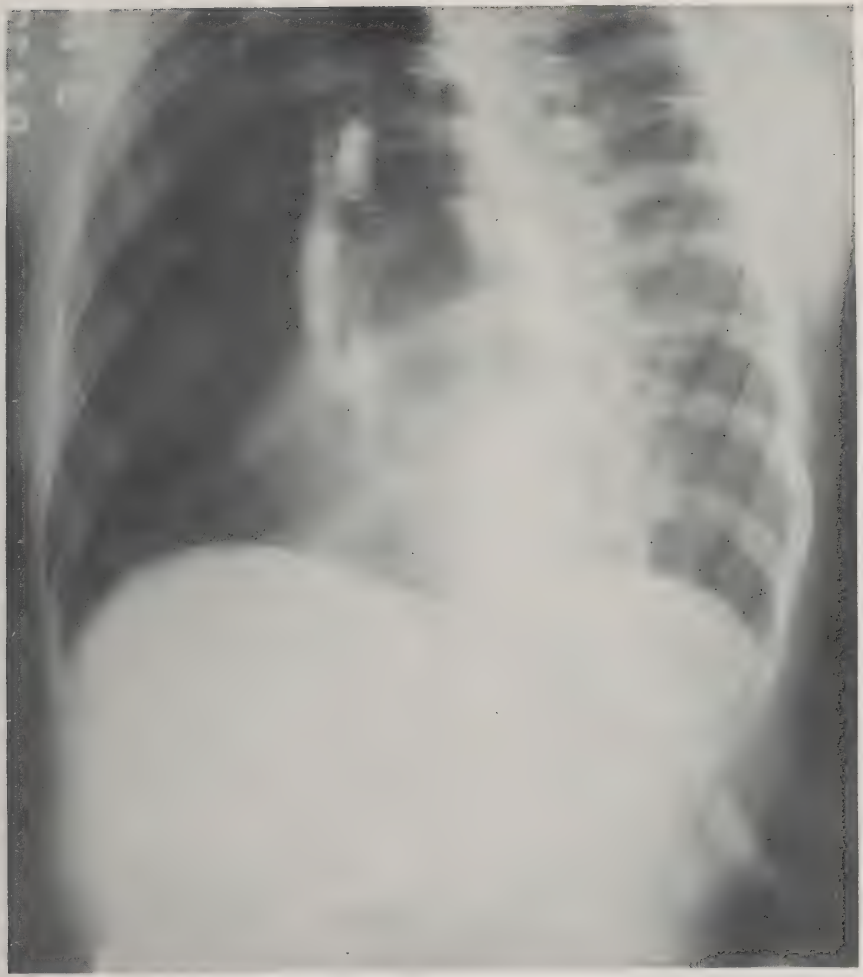


FIGURE 89.—Retrosternal, oblique study. (Note distinct visualization of two enlarged lymph nodes provided by this study.) (See fig. 88.)

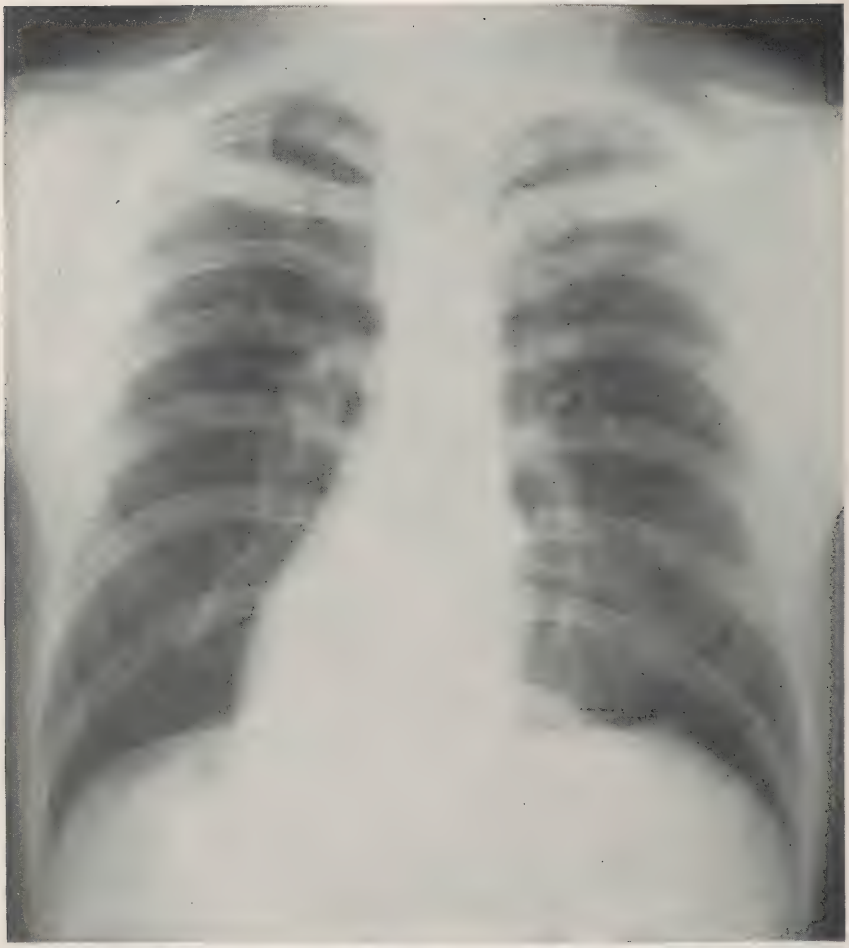


FIGURE 90.—Septation of inferior accessory lobe. (The strands indicated by the arrows are not infrequently interpreted as pleural adhesions but they should be recognized as septa associated with the inferior accessory lobe.)

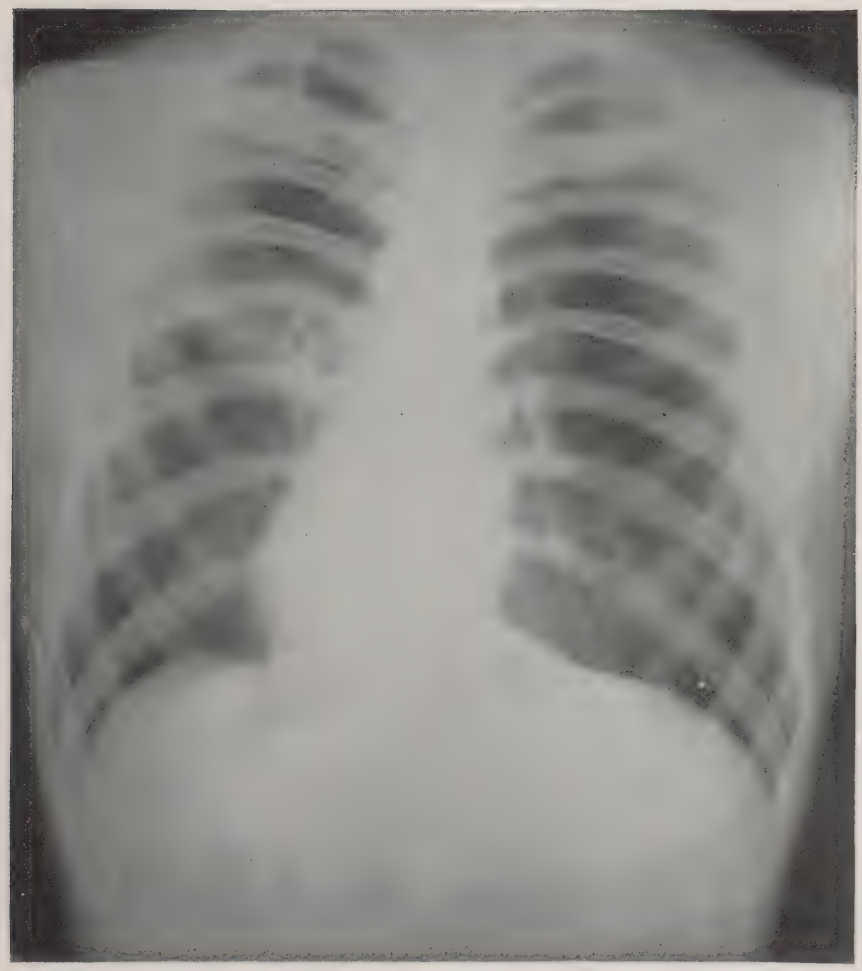


FIGURE 91. Platelike atelectasis. (Note compressed strand extending horizontally across left mid-lung zone and absence of regional infiltration.)

l. The outline of a cross section of a bronchus may present the appearance of a cavity.

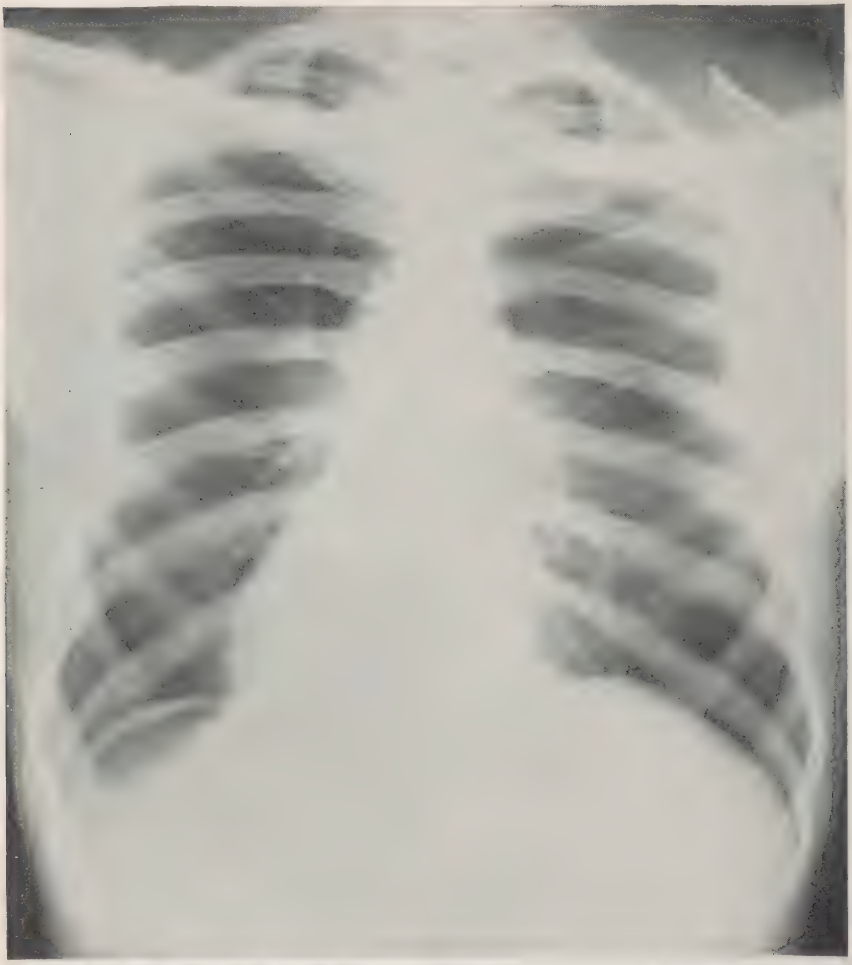


FIGURE 92.—Cross section of large bronchus. (Note circular outline in paraspinal region of right seventh interspace. These configurations should be recognized as cross sections of a bronchus. They are easily identified by stereoscopic studies or by making comparative studies, varying the relative position of the focal spot.)

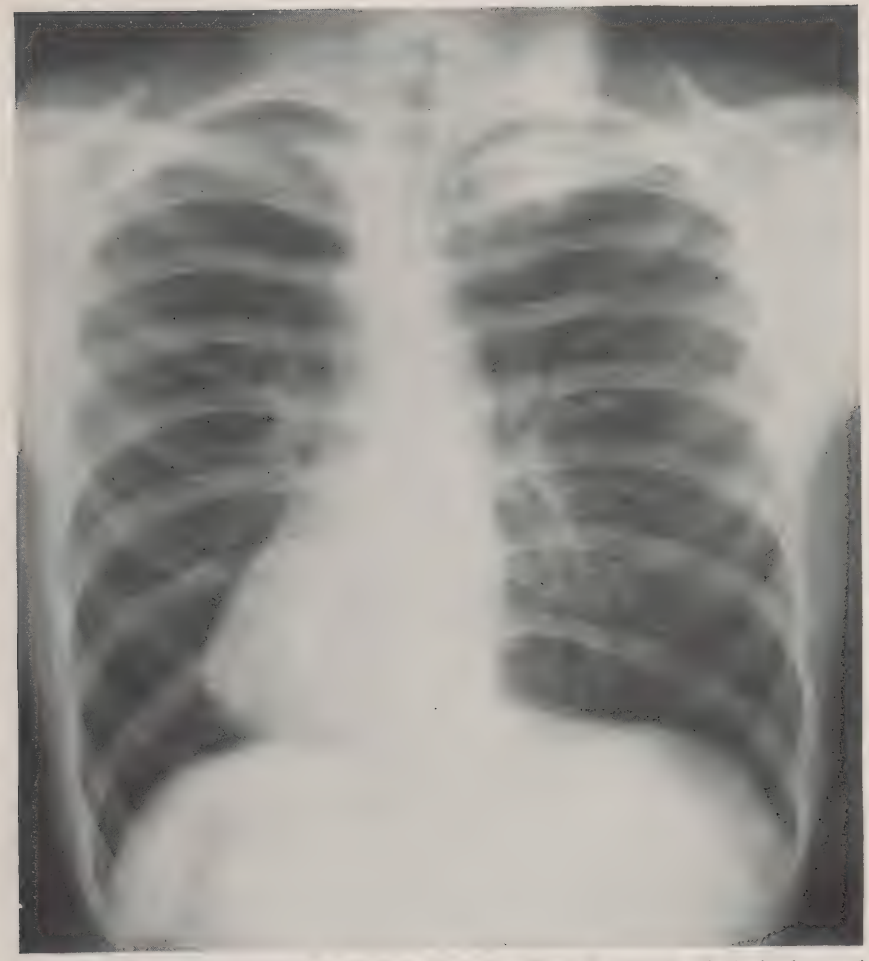


FIGURE 93.—Prominent trunk of pulmonary artery. (Due to contrast of air in front of the trunk of the left pulmonary artery, this vessel may be conspicuously visualized and in some cases falsely presents the appearance of an enlarged lymph node.)

Section VIII

ROENTGEN THERAPY [1]

57. General.—*a.* Relatively long wave length X-ray therapy may be indicated for certain infections and dermatoses which may be encountered in the field of combat. One should not expect to be encumbered with the treatment of neoplasms in the forward zone. Therefore, as far as the requirements of the mobile surgical hospital or the evacuation hospital are concerned, high kilovoltage and high filtration X-ray therapy need not be provided.

b. The regulation of the high-tension transformer included with item No. 96085 and the design of its autotransformer provide for kilovoltages as high as 100 with a milliamperage load of 4. It has been found that the shockproof cables of the first lot of these units do not tolerate more than 90 kvp. These particular shockproof cables can be identified by their having full-length outer metallic sheathings. Later constructions include shockproof cables of more substantial dielectric strength and these can easily tolerate a kilovoltage of 100 with the load of 4 milliamperes. These latter shockproof cables can be identified by the fact that outer metal sheathings cover only 9 inches of each of their extremities. Regardless of the fact that considerable reserve of dielectric strength is being provided with the latest type of cable, it is important that the radiologist bear in mind that the X-ray performance of this machine is by way of self-rectification. In case a load greater than 4 milliamperes is imposed, two maleffects would be incurred: added punishment would be imposed upon the target of the X-ray tube; and the difference between the useful voltage and the inverse voltage would be increased, thereby subjecting the shockproof cables to potentials considerably greater than 100 kvp for each unused half cycle. In the same way, excessively high potentials would be imposed by disregarding the limit of 100 kvp. useful voltage, and permitting higher settings. Thus it is important that the limits, 100 kvp and 4 ma., are not exceeded. However, these capacities may be tolerated continuously.

[1] As provided with the standard X-ray machine unit, item No. 96085.

58. Dangers.—*a.* Three phases of danger are to be considered with respect to this type of X-ray therapy:

(1) X-radiation dangers as far as the technicians and attendants are concerned.

(2) X-radiation dangers as far as the patient is concerned.

(3) Electrical dangers for those in contact and break-down of the equipment.

b. The maleffects of X-radiation are described in the National Bureau of Standards Handbook HB–20, and TM 8–240. It must be emphasized that when operating with kilovoltages as used for X-ray therapy the X-rays concerned with the primary beam are much more penetrating and much greater in quantity than are those used for roentgenography and that, moreover, the shorter wave lengths of the therapy range are productive of considerably more secondary radiation, which is injurious to those who receive repeated exposures. The X-ray technician who is delegated to perform these duties should be instructed to operate the unit at the greatest possible distance from the primary beam and from the patient (see fig. 94), and at all times the primary beam should be directed either downward or in a direction away from the operator. Similar consideration should be given to other attendants in a ward as well as to nearby patients. It is realized that lead protective panels will not often be available but should they be, their protection should be utilized. It is important that frequent blood counts be made of technicians engaged in this type of work. These examinations should be accomplished at least once a month and they should include both a red cell count and a white cell count.

c. Though the quality of the X-rays as developed with a kilovoltage of 100 is considered to be of short wave length as compared with the wave length utilized for roentgenography, nevertheless these wave lengths are relatively long as compared with the usual X-ray wave length utilized in roentgenotherapy. It is impractical to use filters greater than 3 to 5 millimeters of aluminum. With no added filtration and even with this amount of filter added, the wave lengths are of a quality such as to be the most destructive of any wave lengths used for X-ray therapy. It should be a very definite rule that the total dosage (summation dosage) must never exceed 400 r-. Moreover, the treatment field should be limited to the utmost. All portions not requiring treatment should be protected, utilizing the limitations of lead diaphragms (as contained in the metal carbon which is used for packing the shockproof cables) or utilizing the protection of lead aprons or sheet lead which may be available.

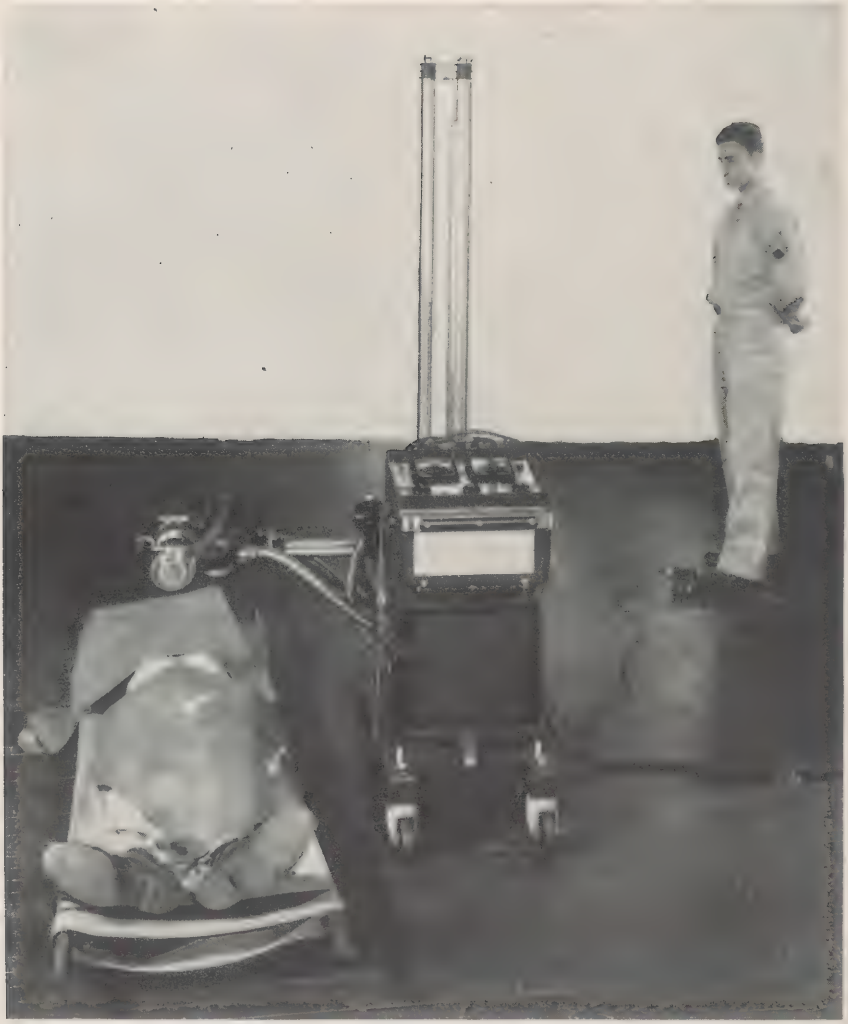


FIGURE 94.—Roentgenotherapy as administered in the field. (Note protection given patient, except for limited areas where X-radiation is desired. Also note that protection to operator is accorded mainly by distance and his precautions as to positioning the X-ray tube properly.)

When fields larger than 10 by 10 inches must be used, the summation dose should be limited to 300 r-. Before giving any X-ray therapy it is well to inquire of the patient and his records as to the type of treatment previously received. If previous X-ray therapy has been given or if solutions irritating to the tissues (such as, bichloride of mercury, Dakin's solution, or tincture of iodine) have been used, X-radiation should be started with the utmost of caution or not at all.

d. Even though this equipment is shockproof in design, several precautions must be exercised to provide for trust of the shockproof features. The ground wire, which is connected to a clip and adjacent to the wall plug, should be securely fastened to a metal housing such as is usually found at the wall receptacle, or to a water pipe or radiator. Electrical break-down is likely to take place in sites of strain such as produced by sharp angulations. Therefore, both for electrical security and preservation of the shockproof cables, precaution should be exercised that all kinkings and sharp angulations are smoothed out or avoided.

59. Types of lesions warranting this treatment.—*a.* Long wave length X-ray therapy of the type generated by this machine unit should be considered only for infections, dermatoses, and the most superficial (skin surface) neoplasms.

b. Some of the infections which may be encountered in the zone of combat are gas gangrene, aerobic cellulitis, including erysipelas, subcutaneous abscesses, carbuncles, furuncles, lymphogranuloma venereum, lymphangitis, lymphadenitis, and even thrombophlebitis (only the acute stage should be treated with X-ray therapy). It should be realized that the more acute the process, the more responsive it is to X-ray therapy. Moreover, the more acute the process the less treatment dose will it tolerate. For very acute lesions, it is well to limit the dosage to 50 r- for any one seance and to repeat such treatments twice daily, in the early morning and in the late afternoon. For less acute lesions, it is well to consider 75 r- as the average single treatment dose and to treat once a day or at intervals of a few days.

c. Before treating any dermatoses, a differential consideration should be given to the possibilities of parasites having been responsible. With the congestion of mobilizations, parasitic dermatoses can be expected to be of high incidence and X-ray therapy has no place in their treatment. Neither should X-radiation be used for treating chronic recurrent lesions such as psoriasis or chronic eczemas. Some of the dermatoses which might be considered for X-radiation therapy are acute folliculitis, pyogenic or mycotic sycoses, acute

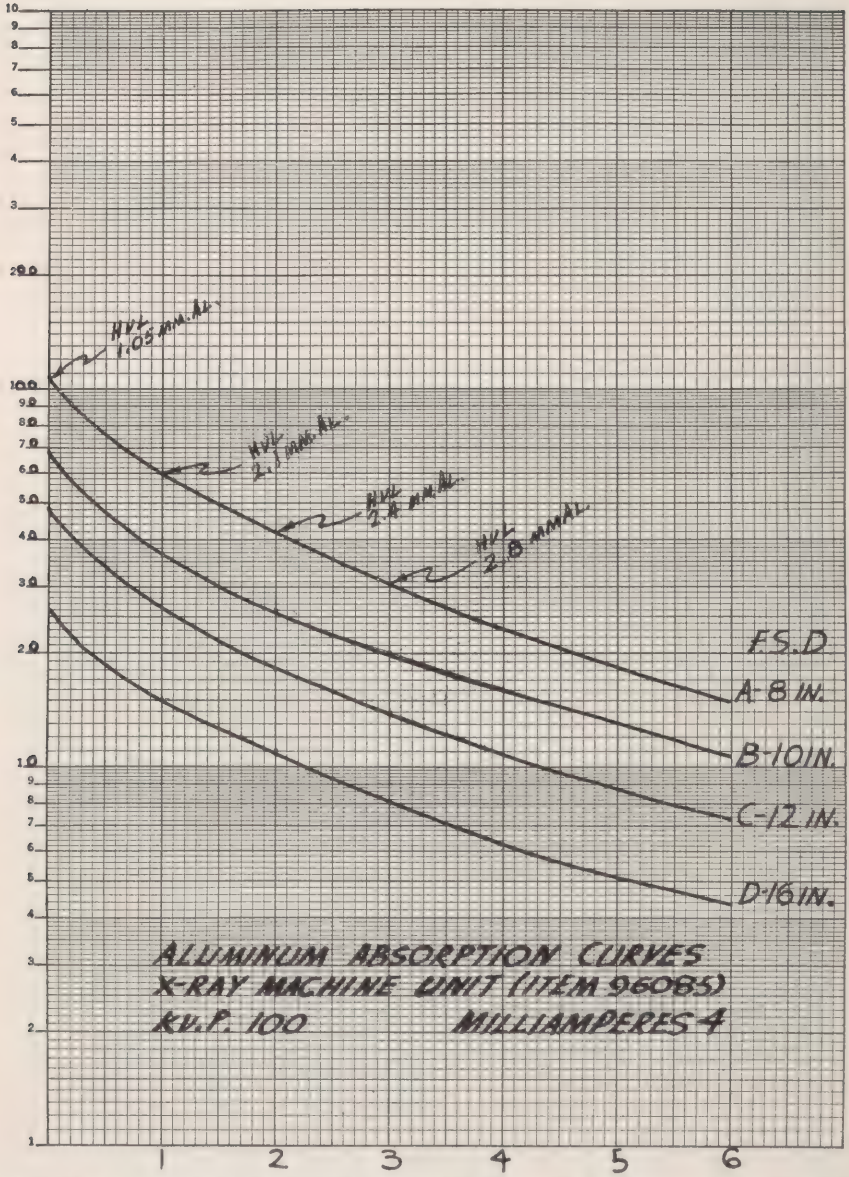


FIGURE 95.—X-radiation performance of average unit (item No. 96085), with considerations of deliveries of X radiation through various filters provided and at various practical focal skin distances. (The quality of X-radiation is thus also indicated in terms of half value layers. All these measurements were made in air without allowance for backscatter.)

dermatomycosis, acute eczemas presenting intolerable pruritus, and herpes (simplex and zoster). X-ray therapy can be expected quickly to alleviate the annoyance by any of these lesions and to involute these processes within a few days. It must be realized, though, that relatively large fields may be required and therefore particular precautions must be taken in order to avoid an overdosage (which might produce not only local injury but depletion of blood cells).

d. While it is not reasonable that superficial malignancies should be treated in the field, nevertheless they may be treated in the general hospitals with the use of this equipment. For them, it is most important that the treatment field be constricted to the minimum, for very large total dosage is required to get results. For basal cell carcinomas, the total dosage should be 4,000 to 6,000 r-; for squamous carcinomas, it should be 5,000 to 7,000 r-; while for adeno cystic carcinomas, it should be 6,000 to 8,000 r-. Pre-biopsy radiation to the extent of 1,500 to 2,500 r- should be applied (may be given at one time) and a biopsy should then be obtained. These treatments may be divided (particularly if the dimensions are larger than 2 centimeters in diameter) but the total dosage should be administered within a time limit of 2 to 3 months. Drainage channels and regional lymph nodes should not be treated with this quality of radiation except insofar as treatment of secondary infection might be considered. When such is evident, it is well to precede the treatment of the neoplasm itself by treating the infection. The regimen of this treatment is indicated in *b* above.

60. Collateral treatment.—Some degree of injury is always produced by X-radiation. Benefits attributable to X-radiation are derived by way of injury to one or another tissue. This fact emphasizes the importance of providing supportive treatment. X-radiated skin will not tolerate bichloride solutions, tincture of iodine, or similiar irritating antiseptics. Even moderate and certainly excessive heat and sun radiation should not be superimposed. Ichthyol ointment (10 percent) may well be tolerated, particularly in conjunction with X-ray therapy for the superficial infections. It may serve to restrict the flow of virulent organisms along sweat channels. For weeping surfaces or where sweat is annoying, Dodd's lotion may be beneficial. It consists of the following:

Phenol	2
Glycerin	12
Zinc oxide	24
Lime water	240

61. Dosage calibration.—It has not been possible to calibrate each individual X-ray machine unit. Average values are given in figure 95. It must be realized that the performance of the individual units vary as much as 10 percent plus or minus in relation to the values indicated.

SECTION IX

PROTECTION AGAINST X-RADIATION HAZARDS

62. General.—*a.* It is a widely known fact that a single large exposure to X-radiation or repeated small exposures to it may produce tissue injuries such as dermatitis, endothelial changes with the possibility of ulcer formations or neoplastic developments in the skin, destruction of blood cells, inhibition of the hematopoetic system (with the production of an anemia or leucopenia), neoplastic changes of it (with the production of a leukemia), inhibition of glandular activities (in particular, of the reproductive glands), and actual deformations of a growing fetus. Besides these effects, there is substantial reason to believe that latent malconsequences may occur, these being concerned with genetic cellular function. This latter effect may prevent survival of tissue developments or it may lead to abnormalities of development—abnormalities in the individual and eventually in the race. These facts might be emphasized by quoting some of the statistical data obtained by Hickey and Hall. On the basis of a questionnaire distributed to radiologists and radiation workers, it appeared that the incidence of sterility among them amounted to 36.6 percent, even though in most instances it was only the father in the family who was exposed to the X-radiation. Moreover, these investigators reported an increase in the incidence of abnormalities in the offsprings from 2.6 percent of those born prior to radiation contacts to 4.0 percent after such contacts.

b. Very severe injuries to the superficial tissues and numerous deaths have occurred because of X-radiation exposures, particularly during the first two or three decades following the discovery of the X-ray. The dangers were then not realized: maleffects were due to

ignorance as to the biological sequelae. The martyrs of those days were responsible for the incorporation of numerous protection features into the design and construction of equipment. Most of these provisions have been concerned with protection against the X-rays emitted from the X-ray tube itself—the primary X-rays. Ordinarily, too little consideration has been given to secondary radiation—the X-radiation which is emitted from table parts, the patient, and equipment in the exposure room.

c. Considering all sources and types of X-radiation, a comprehensive evaluation of the threshold limits for the human (that is, the maximum daily tolerance which may be incurred without the development of maleffects) is not available today. One might consider limits of exposure which could be tolerated by the superficial tissues of a portion of the body, the limits of tolerance to whole body radiation wherein not only the superficial tissues but also the blood-forming organs and blood cells become affected, or the maximum dosage tolerated by the reproductive glands. A variety of investigations and experimental studies have been conducted by such authorities in X-radiation physics as Kaye, Taylor, Failla, Quimby, Henshaw, Packard, Scheele, and Cowie, and committee members have been selected by leading radiological societies to study this problem in the United States and in Europe. At intervals since 1921, recommendations have been submitted by them. There has been some variation as to their interpretation and definition of the maximum daily tolerance dosage. However, it has always been considered to be of very small quantity and in more recent years there has been a definite tendency toward downward revision of this quantity. Depending upon the prospective, whether dealing with protection for one or another tissue or for all tissues of the body, the maximum daily tolerance dosage has been considered to be one or a few r-, 0.2 r-, 0.1 r-, or even as little as 0.02 r- per day.

63. Primary versus secondary X-radiation.—Short wave length X-radiation is to be most seriously considered as far as the deeper tissues are concerned. The superficial tissues bear the brunt of the longer wave length X-rays. Therefore, within the realms of fluoroscopy and conventional roentgenography, daily small exposures or any prolonged single exposure to X-rays of the primary beam must be avoided. Not infrequently, too much reliance is bestowed on the manufacturer and too much trust is given to the construction features of equipment. It is possible to eliminate exposures of the examiner to the primary beam but it is not possible to eliminate entirely exposures by the secondary rays.

64. Exposures during fluoroscopy.—The Army roentgenologist is responsible not only for providing protection to himself but he is also responsible for enforcing the maximum protection to the patient, his roentgenographic technicians, and other assistants. No doubt, the greatest amount of punishment by X-radiation is received in the fluoroscopic room. There, during routine procedures, X-rays are being emitted from the table and from the patient and to a lesser extent from practically all objects in the room. Too often the radiologist considers himself too rushed to bother with the ordinary precautions of putting on a lead apron or using a pair of lead-impregnated gloves. Too frequently his technician is allowed to stand close to the patient and the table without any protection whatsoever. Occasionally instructions are given that the technician subject his hands or portions of his body to very close proximity of the patient or even to the primary beam for such purposes as holding an enema tubing, syringe, or other instruments. There is seldom any substantial reason for having the technician thus exposed. When necessary, ample protection with lead gloves and a lead apron should be provided.

65. Surgery with fluoroscopic visualization.—In some institutions, fractures are still being reduced under fluoroscopic observation. Foreign bodies are being removed in the same manner. Such practices can only contribute to the large numbers of medical martyrs in this field. There was excuse for the many catastrophes of this sort in the early days of radiology, but there should be no excuse for repetitions of the mistakes made in those days, now that the treachery of X-radiation is understood.

66. Exposures incurred during photoroentgenography.—Careless practices are likely to appear at induction examining centers. Personnel are faced with a new problem—the handling of chest examinations of large numbers, requiring as many as 400 to 800 exposures within an 8-hour day. Mobile lead shields are provided and their proper use must be observed. The fact is recognized that considerable secondary radiation may be reflected from the walls of the room and that in certain positions the lead shields provide only false security. Moreover, personnel must be alert to the possibilities of careless exposures particularly by the technician who is charged with the positioning of the candidate and also the technician whose responsibility it is to exchange the films (see sec. VI).

67. Exposures during conventional roentgenography.—Lesser degrees of exposure are ordinarily encountered during conventional roentgenography. Occasionally, though, the technician care-

lessly operates a timer or X-ray switch at a distance which is too close to the patient and the X-ray tube. These practices must be avoided, and every effort should be made to utilize the full length of a timer cord or spacing of the control from the X-ray tube in order to allow the factor of distance to serve as one of the measures for protection.

68. Protection features of field X-ray equipment.—A number of features have been incorporated in designing field X-ray equipment to provide for protection. Some of these features are as follows:

a. For fluoroscopy, there is a fixed focal-fluoroscopic screen distance (66 centimeters). This feature in the table unit (item No. 96145) serves to obviate malalinements of the primary beam or changes in the coverage of it by the fluoroscopic screen as might apply in case the fluoroscopic screen were allowed to move independently in relation to the X-ray tube. Many have advocated the use of a bonnet type of fluoroscope which might be carried on the head of the operator, thereby providing for conducting these activities in a lighted room. This plan and others similar to it were rejected for the very reason that they would incur too great a hazard of X-ray exposure.

b. The coverage of the fluoroscopic screen is 12 by 16 inches, thereby providing not only for a large fluoroscopic field but also for the maximum practical protection with respect to secondary radiation adjacent to the field of study. Many have recommended that in order to reduce the weight to a minimum and to facilitate the exchange of patients, the dimensions of the fluoroscopic screen should be 10 by 10 inches, as used in the World War. It was believed that the attributes of providing for protection against X-radiation outweighed the attributes of the smaller sized screen.

c. For foreign body localization, marking of the skin surface is provided by a marker which can be manipulated *beneath* the fluoroscopic screen but without exposing the hands of the operator to the primary beam. This is made possible because, with the method of localization which is used, the distance between the fluoroscopic image and the skin surface is subtracted and it is not necessary to position the fluoroscopic screen directly upon the skin surface. If it were necessary to position the fluoroscopic screen directly upon the skin surface, a perforation for admitting a skin marker would be required, as was the case with the equipment used in the World War.

d. Stops are provided so as to limit the opening of the fluoroscopic shutters and thereby limit the maximum spread of the primary beam to the extent that at the level of the fluorscopic screen its area is confined to within 1 inch of the inside borders of the screen mounting.

Thus, even with the most careless operation of the shutter controls, it is not possible to deliver a primary beam of such wide coverage as to permit escape of primary X-rays beyond the limits of the protection provided by the fluoroscopic screen and its lead-protected glass (protection equivalence of no less than 1.5 millimeters lead).

e. The fluoroscopic screen and the X-ray tube are mounted on a C-shaped support which is adjustable in the vertical plane, thereby providing for varying the focal-skin distance and utilizing the greatest focal-skin distance possible for localizations—and the least part screen distance. This feature serves for minimizing X-radiation exposure upon the patient and reducing thereby secondary radiation from the tissues, while providing for the greatest degree of sharpness of detail for the fluoroscopic image.

f. The X-ray tube housing is impregnated with opaque material to such an extent that except for the portal intended for the primary beam, protection of the equivalence of 1.5 millimeters of lead is provided. This degree of protection should be adequate to filter X-rays of wave length as short as those produced with the kilovoltage of 100—the maximum kilovoltage provided with the unit.

g. Through the portal provided for the primary beam, the combined inherent filtration is equivalent to that of 0.5 millimeter aluminum. This filtration consists of the wall of the insert tube (1 millimeter of pyrex glass), a thin layer of oil (1.5 millimeters), a 1.5-millimeter transparent bakelite wall, plus an added fixed filter of 0.25 millimeter aluminum.

h. For fluoroscopy, in addition to the filtration just described, there is a second fixed filter of 0.5 millimeter aluminum. This filter is fixed into the housing of the fluoroscopic shutters. Thus, the total filtration during fluoroscopy is consistent with the stipulations contained in paragraph 2.03 of handbook HB 20 as compiled by the advisory committee on X-ray protection and published by the National Bureau of Standards.

i. The shutter controls are contained in the vertical portion of the C-shaped supporting member, referred to above, thereby providing for distance between them and the primary beam and the sources of secondary radiation. This feature serves to minimize the exposure incurred by the examiner's forearm and moreover it lessens the tendency for him to lean closely against the fluoroscopic screen whereby he would receive more extensive exposures to other portions of his body.

j. The method of foreign body localization is such that only three short exposures for alinements are required. The localization pro-

cedure can easily be accomplished within 30 to 45 seconds whereby even with the very shortest focal-skin distance (10 inches) a reasonable estimate of exposure incurred by the skin of the patient would be approximately 15 r-. The reading of the depth scale and the calibration scale can be made only while the X-ray exposure is interrupted, this feature being in contrast to so many methods which provide for reading of measurements with the assistance of the fluorescence from the fluoroscopic screen. (The light intensity of the pilot lights should be kept at a minimum and they should emit dim yellow or faint red light in order to preserve the visual acuity of the operator to the utmost.)

k. A limiting resistance is incorporated into the foot switch whereby the maximum milliamperage load is 5 milliamperes at 85 kvp. It is realized that well-qualified roentgenologists will properly prepare their eyes by wearing dark goggles or by remaining in darkness for at least 5 to 10 minutes before starting fluoroscopy. They will thereby develop an acuity of vision not requiring excessive kilovoltages or high milliamperages and they will accomplish fluoroscopy with kilovoltages of 65 to 80 and milliamperages of 2 to 4 (that is, fluoroscopy of extremities with 65 kvp and 2 to 3 ma.; fluoroscopy of the chest at 70 kvp, and 2 to 3 ma.; that of the abdomen, 80 kvp and 3 to 4 ma.). The milliamperage limiting device has been incorporated for protection in case of heedless activities which might pertain to the stress of activities in the theater of operations.

l. The fastest type of fluoroscopic screen is provided, thereby obviating the need for relatively great X-radiation exposures.

m. The table top is a standard United States Army litter. It is constructed of materials of low atomic densities—canvas and aluminum—rather than having a wide coverage of plywood or bakelite and metal framework. The secondary X-radiation emitted from the litter type of table top is considerably less than that emitted from conventional table tops and thus this source of secondary radiation is reduced and the radiologist is spared.

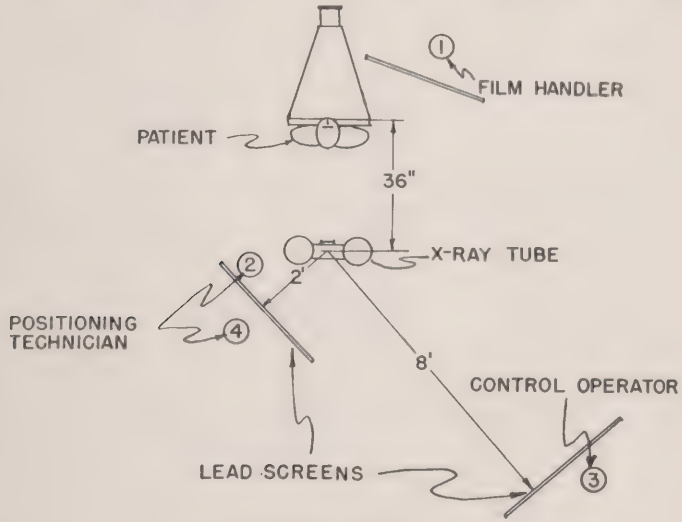
n. A lead apron and a pair of lead-impregnated gloves are constituents in the chest which accommodates the control unit of the X-ray machine. Thus it is certain that at least one lead apron and one pair of gloves will be taken to every installation where the X-ray machine unit is to be operated. The United States Army does not suggest but it enforces the wearing of a lead apron and lead-impregnated gloves for this work. Samples of these items are tested at the Army Medical School and unless their quality is up to a standard, including the requirement that a single thickness of either provide

for protection equivalent to 0.5 millimeter lead, these items are rejected. The supporting straps of the aprons provide for suspension from one shoulder to the opposite hip, rather than the neck-band type, thus providing for the maximum of comfort in the wearing of these rather cumbersome garments. The standard gloves have a length of 37 centimeters rather than the somewhat shorter glove which is commonly used in many clinics.

69. Limitation of protection by lead aprons and lead-impregnated gloves.—It is important to realize that if one were to attempt to provide complete protection from the X-rays used in fluoroscopy, it would be necessary to incorporate lead or other opaque media of twice the thickness and weight ordinarily incorporated into lead-impregnated aprons or gloves. Such an addition would result in uncomfortable weight and impractical rigidity and it is believed that not a few radiologists would be annoyed by the use of them. Too many would discard them and expose themselves unduly. The lead apron is intended to protect against secondary radiation. No one should expose himself, even behind a lead apron, to the primary beam. Neither should the hands be subjected to the primary beam, even though protected by lead-impregnated gloves. The amount of radiation which actually traverses an interposed portion of the body of a patient and, thereafter, a thickness of a lead-impregnated glove such as supplied to the United States Army would be minimal, and from all testings it appears that even after a strenuous day barely a threshold dosage of X-radiation would be incurred by the tissues of the hands; nevertheless, it must be recognized that some of the X-rays definitely do penetrate these protective gloves, and every effort should be made to accomplish manipulations by the gloved hand in a position peripheral to the actual limits of the primary beam.

70. Checking as to X-radiation exposures.—*a.* A quick analysis of the escape of X-radiation into one or another portion of a room wherein fluoroscopy or other types of roentgenographic activity are conducted can be accomplished, when the room is darkened, by merely positioning a fluoroscopic screen toward the source of the radiation and by testing as to the penetration of the rays by placing an object of varying densities between their source and the fluoroscopic screen. Every roentgenologist should conduct such a survey with his equipment in order to put him on guard. A more quantitative indication would be that he and his assistants wear a dental film (with the emulsion side away from the body) having a lead number or metal object fixed to the outside of the film packet. Such a film should be

processed after a week or so. If the metal object is visualized on a background of dense blackness, it can be realized that at least 2 r- have been received, which value over a period of 5 or 6 days must be considered excessive. It should be routine practice that a platelet count and white blood cell count be obtained on all who operate X-ray equipment, at least once every 3 months. These studies should be



10 PATIENT RUNS
STEREOSCOPIC EXPOSURES
80-90 KV.P.

	NO GRID 20 EXPOSURES—400 MA.S.	GRID 20 EXPOSURES—800 MA.S.
①	.0045 R	.010 R
②	.025 R	.050 R
③	<.001 R	.001 R
④	<.001 R	.001 R

FIGURE 96.—Radiation exposures incurred by technicians. (The values listed represent average values obtained as a result of several testings. The X-radiation exposures will vary, depending upon the arrangement of the mobile lead shields and the positioning of the various items of X-ray equipment.)

made immediately upon hearing of complaints such as easy fatigability or noting lack of application to duty by the personnel.

b. In general, the same regard should be given to those who are constantly subjected to small quantities of X-radiation as would naturally be given to professional blood donors. Such individuals should have exercise in the open during at least two afternoons a week and they should see to it that their diet is well balanced, including green vegetables and meat. Liver, kidney, and heart should be frequent items in their menu.

APPENDIX

Examination	Initial preparation	Medium used	Roentgen studies	Subsequent considerations
Gastro-intestinal tract:		Barium sulphate (U. S. P.).		
a. Esophagus	No food nor fluids previous 8 hours.	Thin meal: Barium, 1 part (vol.). Water, 2 parts (vol.). Thick paste: Barium, 6 parts (vol.). Water, 1 part (vol.).	Fluoroscopy: Use drinking tube; patient (recumbent and obliquely to left or prone). Patient standing or recumbent.	Perhaps need for lavage and aspirations followed by reexamination.
b. Stomach	Quiet tract for 24 hours—no carth-arsis; neither food nor fluids for previous 8 hours.	Barium, 1 part (vol.). Water, 2 parts (vol.). 8 to 16 ounces total volume during fluoroscopic filling.	Fluoroscopy: Preliminary swallow and study of esophageal and gastric relief; subsequent addition of volume.	Positional roentgenography (or spot films); 4- to 6-hour study; thereafter fluids and food—then 24-hour study.
c. Small intestine.	As above	As above (cold distilled water recommended). 4 to 8 ounces total volume.	Roentgen study every 15 minutes (4 such); then every half hour, as indicated.	
d. Obstructed cases.	Miller-Abbott or similar tube for suction drainage.	None	Fluoroscopy and roentgenography: Recumbent, lateral decubitus and upright.	May inject (thru the tube) small quantity (50 to 100 cc) thin barium.
e. Colon	Repeated 1 percent saline enemata (warm tap water) until clear return, 2 hours prior to the examination. No solids previous 12 hours.	Tepid thin barium mixture: Barium 8 ounces, water 2 quarts, acacia ½ ounce—all volumetric.	Fluoroscopic control of filling; reexamination after evacuation; possibly air injection (under fluoroscopic control).	Roentgenography following each phase. In cases of obstruction, give mineral oil—2 ounces b. i. d. and high enemata b. i. d.—until barium has been eliminated.
Gall bladder	Fat-free diet; high carbohydrate intake for previous day. Tetra-iodophenolphthalein (quantity in accordance with weight) with fruit juice, 14 to 16 hours prior to examination.		Roentgenography: 14 to 17 hours following intake of dye; again, 1 to 2 hours following fatty meal (yolks of 2 eggs and equal quantity of cream).	If excessive gas, recommend enemata or pitressin (unless contra-indicated), 8 to 15 minutes and restudy. In case of vomiting or diarrhoea, recommend paregoric, 1 to 2 drams and repeat. Give double dose if single dose fails; possibly intravenous dye.

Examination	Initial preparation	Medium used	Roentgen studies	Subsequent considerations
Urinary tract:				
a. K. U. B.	Repeated enemata may substitute licorice powder, 2 to 3 drams or castor oil, 1 to 2 ounces, at least 20 hours prior to study. Pitressin (8 to 15 minutes) ½ hour prior to study—in cases of flatulence.	None	Roentgenography: Recumbent, A-P, oblique and occasionally erect.	A-P and oblique films with ureteral catheters inserted (to study for calculi).
b. Pyelography:				
(1) Intravenous.	As above; restrict fluids for at least 6 hours.	Intravenous dye (of reputable manufacture), following "control" roentgenography. Make preliminary skin test; have adrenalin ready.	Recumbent studies: Preliminary film (control); 5 minutes, 15 minutes, 30 minutes (patient erect), and 1 hour.	Films at 60 and 90 minutes in cases with poor renal function.
(2) Retrograde	As above, no restriction of fluids.	5 to 12 percent sodium iodide or commercial dye (20 percent).	Preferably, fluoroscopic study of filling - retract catheters sacroiliac level. Roentgenography: supine with 15° Trendelenberg; horizontal and 45° Fowler, plus deep inspiration, or sitting position	15-minute interval films following withdrawal of catheters until pelves emptied (patient in Fowler position or erect).
c. Cystography	Enemata; bladder lavage (1 percent warm saline).	2 to 5 percent sodium iodide—200 to 300 cc.	Roentgenography—before and after voiding: A-P, P-A and obliques.	Possibly oxygen injection studies.
d. Urethrography.	Catheterization and irrigation of bladder.	5 to 12 percent sodium iodide—injected during exposure.	Roentgenography: Patient in semi-Fowler or true Fowler position.	----------
Encephalography (ventriculography).	Sodium amytol, gr. 1 ½ to 3, night before and morning of examination; morphine sulphate, gr. ⅙ to gr. ¼—for adults (children proportionately less); no breakfast.	Air, 120 to 140 cc (by replacement)—40 to 50 cc for ventriculography; air must be filtered.	Stereoscopic roentgenography: P-A, A-P, and laterals—vertical and recumbent.	Ice cap to head; salicyates, codeine and caffeine as needed; fluids and food as tolerated.

Examination	Initial preparation	Medium used	Roentgen studies	Subsequent considerations
Myelography	Sodium amytol, gr. 1½ to 3, night before and morning of examination.	Oxygen (or filtered air), 50 cc or iodized oil (20 to 40 percent iodine content), 2 to 6 cc.	Roentgenography: A-P and lateral stereoscopic films—must be made immediately after injection, if oxygen (or air) is used.	Fluoroscopic observations—patient in modified Trendelenberg and semi-Fowler positions. Needle aspiration of residual oil. 24-hour roentgenography.
Bronchography (1 lobe or single lung study at a time).	Sodium amytol, gr. 1½ to 3, night before; morphine sulphate, gr. ⅙ to ¼ with scopolamine, gr. $\frac{1}{150}$, morning of examination. Cocaine spray (5 percent to pharynx and larynx; 10 percent to Pyriform sinuses); intranasal tube. *Have barbiturate for intravenous injection in readiness to counteract cocainism.*	Iodized oil (20 to 40 percent iodine content)—10 to 30 cc.	Installation of oil under fluoroscopic control. Film studies: P-A stereoscopic, obliques and laterals.	No food or liquids for 2 to 4 hours (until cough reflex is regained); encourage cough to remove oil.

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[A. G. 062.11 (10–9–41).]

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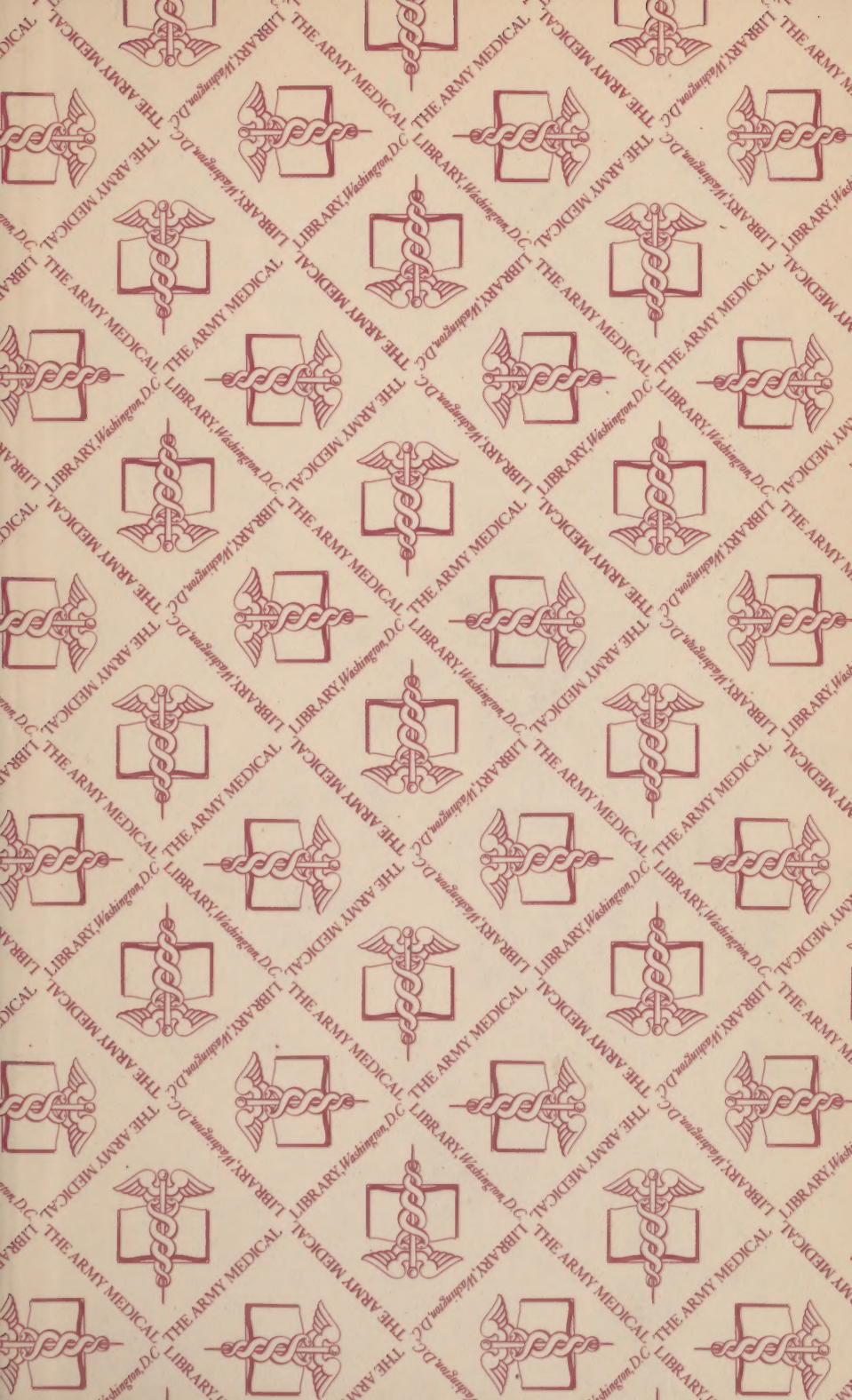
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